The Caribbean Forester

U. S. DEPARTMENT OF AGRICULTURE
FOREST SERVICE
TROPICAL FOREST RESEARCH CENTER
RIO PIEDRAS, PUERTO RICO

VOLUME 19 NOS. 1 AND 2

JANUARY - JUNE, 1958

Caribbean Forester

El "Caribbean Forester", revista que el Servicio Forestal del Departamento de Agricultura de los Estados Unidos comenzó a publicar en julio de 1938 se distribuye semestralmente sin costo alguno y está dedicada a encauzar la mejor ordenación de los recursos forestales de la región del Caribe. Su propósito es estrechar las relaciones que existen entre los científicos interesados en la Ciencia Forestal y ciencias afines encarándoles con los problemas confrontados, las políticas forestales vigentes y el trabajo que se viene haciendo para lograr ese objetivo técnico

Se solicita aportaciones de no más de 20 páginas mecanografiadas. Deben ser sometidas en el lenguaje vernáculo del autor, con el título o posición que este ocupa. Es imprescindible incluir un resumen conciso del estudio efectuado. Los artículos deben ser dirigidos al Líder, Centro de Investigaciones Forestales Tropicales, Río Piedras, Puerto Rico.

Las opiniones expresadas por los autores de los artículos que aparecen en esta revista no coinciden necesariamente con las del Servicio Forestal. Se permite la reproducción de los artículos siempre que se indique su procedencia.

●

The "Caribbean Forester", published since July 1938 by the Forest Service, U. S. Department of Agriculture, is a free semiannual journal devoted to the encouragement of improved management of the forest resources of the Caribbean region by keeping students of forestry and allied sciences in touch with the specific problems faced, the policies in effect, and the work being done toward this end throughout the region.

Contributions of not more than 20 typewritten pages in length are solicited. They should be submitted in the author's native tongue, and should include the author's title or position and a short summary. Papers should be sent to the Leader, Tropical Forest Research Center, Río Piedras, Puerto Rico.

Opinions expressed in this journal are not necessarily those of the Forest Service. Any article published may be reproduced provided that reference is made to the original source.

●

Le "Caribbean Forester", qui a été publié depuis Juliet 1938 par le Service Forestier du Département de l'Agriculture des Etats-Unis, est une revue semestriele gratuite, dediée a encourager l'aménagement rationnel des forêts de la region caraibe. Son but est d'entretenir des relations scientifiques entre ceux qui s'interéssent aux Sciences Forestières, ses problemès et ses méthodes les plus récentes, ainsi qu'aux travaux effectués pour réaliser cet objectif d'amelioration technique.

On accept voluntiers des contribution ne dépassant pas 20 pages dactilographiées. Elles doivent ètre écrites dans la langue maternelle de l'auteur qui voudra bien préciser son titre ou sa position professionnelle et en les accompagnant d'un résumé de l'étude. Les articles doivent ètre addressés au Leader, Tropical Forest Research Center, Río Piedras, Puerto Rico.

La revue laisse aux auteurs la responsibilité de leurs articles. La reproduction est permise si l'on présice l'origine.

*The printing of this publication has been approved by the Director of the Bureau of the Budget (June 26, 1958)

VOL. 19 NOS. 1 AND 2 JANUARY - JUNE 1958

The Caribbean Forester

Contents

Sumario

The Status of Forestry and Forest Research in Puerto Rico and the Virgin Islands

THE EIGHTEENTH ANNUAL REPORT
OF THE
TROPICAL FOREST RESEARCH CENTER 1/

Public forestry in Puerto Rico had its beginnings almost 100 years ago with the establishment of a forestry department under the Spanish regime. In the long period since that time forest conservation has been encouraged and practiced on an increasing scale recently including the Virgin Islands. Current expenditures for this purpose in Puerto Rico and the Virgin Islands are on the order of $500,000 annually, for protection and management of public forest lands, assistance to private forest land owners, and forest research. In spite of the long history and current size of the local forestry effort, the people of these islands seem only slightly aware of their forest problems. This eighteenth annual report of the Center describes these problems and our progress toward their solution.

OUR FOREST PROBLEMS

The forest problems of Puerto Rico and the Virgin Islands concern our most important resources: land, water, timber, people, and money. 2./ Because of the relative size of these two islands areas this description necessarily gives most emphasis to the problems of Puerto Rico.

LAND

The land has been the traditional basic source of income in Puerto Rico. The culture of the soil provides a substantial portion of the food requirements of Puerto Rico, many raw materials for industrial use, and is a large source of employment. Our dense and growing population makes imperative continued and increased productivity of the land.

The great variation from place to place in our climate, soils, and topography makes possible the production of a large number of different crops. This same variation limits the types of crops which can be grown in certain areas. Clean-tilled crops, many of which are high yielding, cannot be produced continuously on steep slopes because of the danger of soil loss by erosion. The area of such steep slopes 1/ in the islands is estimated at 671,000 acres. Other areas cannot or should not be clean-tilled because they are rocky, wet, dry, or infertile, and because other lands, better suited for the production of these crops and adequate to supply our requirements are available. This second category of lands of limited use includes some 358,000 acres. Thus, more than 1,000,000 acres, or nearly half of the land surface of the islands, is unsuited for clean-tilled crops.

If half of our land is unsuited for clean cultivation, how are we to put it to economic use? Those crops which do not require tilling of the soil immediately come to mind. Included are forage, coffee, and timber. Forage and coffee production, where possible, apparently can yield more than timber production, but they are also more demanding in their requirements. On these soils which are unsuited to clean-tilled crops, forage and

1/ Maintained at Río Piedras, Puerto Rico by the Forest Service, U. S. Department of Agriculture, in cooperation with the University of Puerto Rico.

2/ This descriptive statement is based partly upon published and unpublished data from the Division of Forests, Fisheries, and Wildlife, the Water Resources Authority and the Planning Board, all of the Commonwealth Government.

1/ All above 50% slope, nearly all above 60%.

coffee could be marketed from an estimated 505,000 acres. The reminder, some 524,000 acres, not needed or suited for other purposes, can grow forests without detriment to production of other crops under a program of proper land use. Forests have grown and could again grow on all of this area, yet most of this land is virtually idle at present.

WATER

Water has always been and still is a limiting factor in the development of our other resources. In the Virgin Islands water is frequently imported for drinking purposes, and there is insufficient available water for the irrigation of fertile lands or for substantial industrial development. In Puerto Rico some of the urban water systems are inadequate. Hydroelectric power production is frequently limited by a lack of water in the reservoirs. A 26,000-acre area in the Lajas Valley in southwestern Puerto Rico has to the present been low in productivity for lack of irrigation. Recently large demands for water for industrial use are heavily taxing existing aqueduct systems. They may dictate the location of such industries, and are a key factor in the feasibility of many of them.

Our water scarcity is not generally due to a lack of rainfall. Of 13,000,000 acre-feet received each year in Puerto Rico only 1,230,000 or less than 10%, are available as constant river flow. Part of the difference is lost through evaporation, part is used by vegetation (to advantage wherever valuable crops are grown), but about half runs off the soil surface during rains, eroding the soil and racing downstream to the sea. Even though 210,000 acre-feet are used annually in these large irrigation projects, and even though we have 19 hydroelectric power plants, there can be little doubt that we are today putting to effective use less than half of the water we receive. In the Virgin Islands the water supply is less, but use there also is only a fraction of the total amount received.

Our real water problem is to conserve the water we receive until it can be effectively used. Torrential downpours provide us with rainfall more rapidly than it can be absorbed by the soil, so it runs downhill over the surface. This surface runoff is particularly heavy in areas where the full force of the rain directly hits bare soil, becomes muddy, and clogs the pores of the soil or where the surface soil has already been compacted by intense grazing. This surface runoff overloads our streams, overflow our reservoirs, and runs on to the sea, frequently causing flood damage en route. Such water, coming suddenly and unexpectedly in large amounts, and laden with sediment, is virtually impossible to put to use before it is lost. If it is to be stored for use at other times, such as during dry weather, huge man-made reservoirs are required. Our reservoirs, expensive and impressive as they are, store only about 400,000 acre-feet of water each year. Moreover, they are continually losing their precious storage capacity to the sediment which, brought by surface runoff, settles in the bottom.

The best way to conserve our water is to store more of it in that great natural reservoir, the soil. Water which enters the soil, unlike that which runs off the surface to the sea, is not necessarily lost, nor does it cause erosion. While still close to the surface it is available to plant roots. At greater depths it moves slowly toward natural springs or is available for pumping from wells, in either case clear and available in dry as well as in wet weather. This is really useful water. Its storage requires nothing more than the maintenance of a porous, receptive surface layer of soil. This layer can best be maintained by a continuous dense cover of vegetation with a layer of leaf litter on the soil beneath it. Of all crops forest best meets these requirements.

The place to conserve our water is in the uplands where the rainfall is greatest, where because of steep slopes surface runoff is most likely, and where because of elevation stored

water can be put to the greatest variety of uses. The areas which yield the most water are nearly coincident with those areas, already defined, where permanent vegetative cover is needed to protect the soil as well. Those 671,000 acres include the rainiest and steepest areas of the upland. In this area more than 600,000 acres are steeper than 45 percent slope and nearly 500,000 acres exceed 60 percent slope.

The prospect of alternate sources of water, such as the sea, however economically they provide water, would in no way reduce the need for protective vegetation on these critical areas to control soil erosion or to reduce flood damage caused by surface runoff, or to sustain maximum productivity from these lands.

TIMBER

Puerto Rico and the Virgin Islands were once covered entirely by forest. Land clearing for farming and timber cutting made the islands less than self sufficient in timber more than a century ago. Today not more than 5 percent of Puerto Rico and the Virgin Islands is covered by timber forests. Possibly an additional 10 percent is covered with low brush with almost no timber productivity. The remaining forests contain few of the tree species usually considered valuable and almost no large trees. The trees which now are cut from these forests, because the properties and value of their woods are incompletely understood, are generally misused and wasted. Only a very small portion of the yield of our forests is used for lumber. This material must bear the economic burden of inefficient logging, poor sawing, inadequate drying, and a lack of marketing facilities. Scattered smaller trees which, if available in quantity and larger sizes might be worth 60 cents per cubic foot on the stump, are disposed of in small lots for posts at about 4 cents per foot. If we continue to use them wastefully for round timbers, untreated with preservatives against insects and decay, they will never be worth much more than this.

There can be no question that Puerto Rico and the Virgin Islands need more timber than they produce. Annual imports of primary forest prdoucts are nearly 100,000,000 board feet, plus large quantities of manufactured furniture, paper and other products. Consumption per capita is rising.

How much timber could or should we produce? The 524,000 acres of land unsuited to continuous production of other crops, should be used for timber production to the extent that it is economic. Should this area prove insufficient, forests might be grown elsewhere within the 1,000,000 acres requiring protective crops or on any other land where timber growing will outyield other crops.

The approximate location and productivity of the lands unsuited for other crops are indicated in Fig. 1 and Table 1. The 140,000 acres shown as suited for large timber could produce high-value cabinet woods or other types of lumber. The 240,000 acres suited only for small timber are at present believed to be too adverse to produce trees of large size within a reasonable period of time. However, these areas can produce posts, poles, or pulpwood. Some 144,000 acres are so adverse that they are not expected to produce timber economically, at least in the near future. These lands need protective vegetation, however, for soil and water conservation, to make possible their use for outdoor recreation areas, and to protect beneficial wildlife.

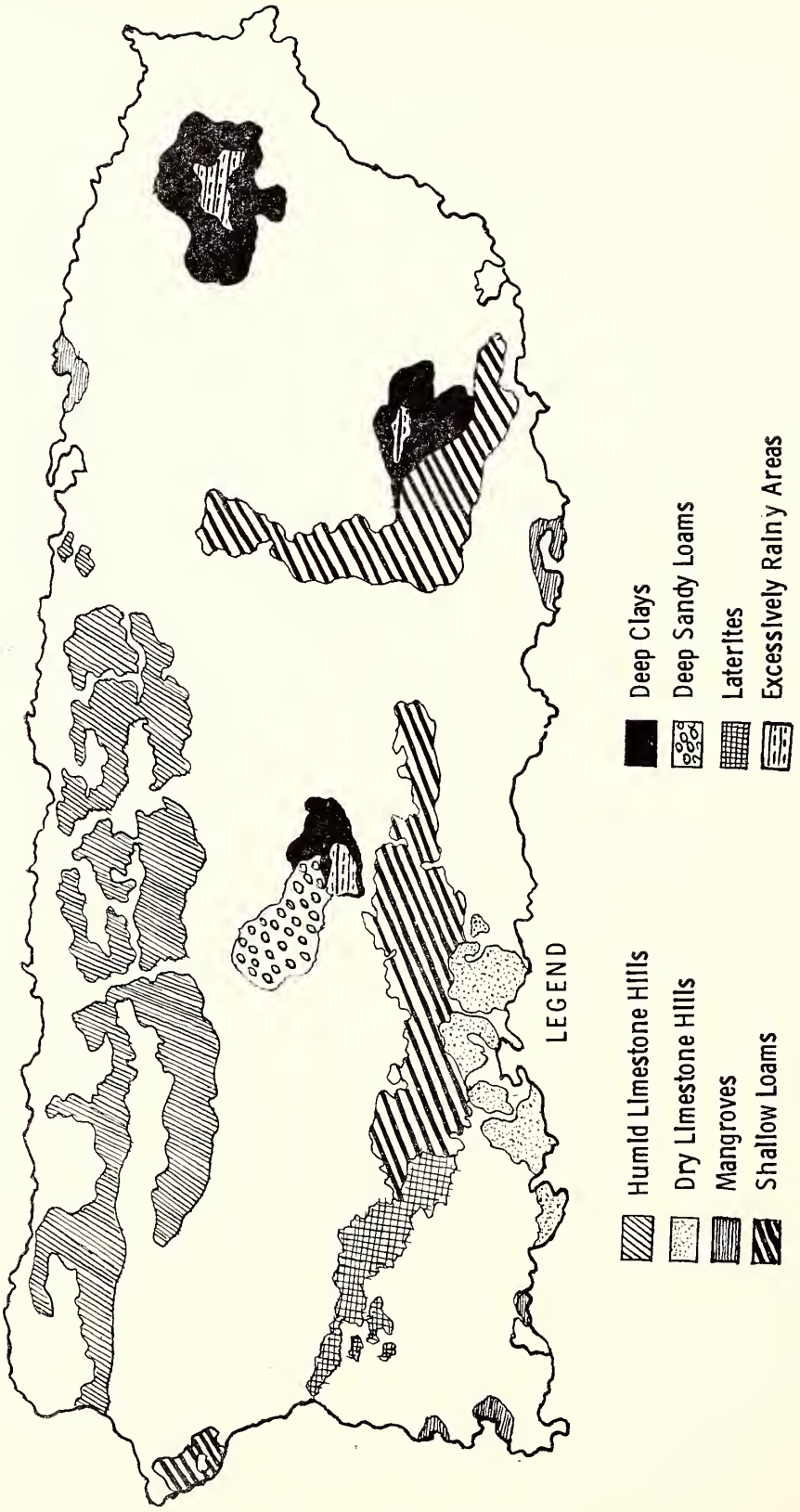

Fig. 1 FOREST LAND AREAS OF PUERTO RICO

FIG. I

TABLE 1 — FOREST LAND AREAS IN PUERTO RICO AND THE VIRGIN ISLANDS

FOREST LAND AREA	LAND AREA SUITED ONLY FOR FOREST		
	Suited for Production		Probably Unsuited For
	Large Timber	Small Timber	Timber Production
	Acres	Acres	Acres
PUERTO RICO			
The Coastal Plain			
Humid limestone hills	54,000	54,000	53,000
Dry limestone hills			
Mangroves		10,000	
The Moutains			
Steep slopes			
Shallow loams		166,000	
Deep clays	41,000		
Deep sandy loams	25,000		
Soils of low productivity			
Laterites			28,000
Excessively rainy areas ..			19,000
THE VIRGIN ISLANDS			
Steep slopes			
Shallow loams	20,000	10,000	
TOTAL	140,000	240,000	144,000

The potential productivity of these 380,000 acres suited for timber crops is difficult to estimate accurately but it is believed to be not less than 15,000,000 board feet of high quality logs and 20,000,000 cubic feet of other products annually. This supply might free the islands from dependence upon importation of furniture wood, piling, line poles, crossties, crates, pallets, millwork, and a number of miscellaneous forest products. New spectacular cabinet woods suitable for veneers and a much-needed wooden novelty industry for both tourists and the export market might be developed. Integrated veneer production with chip-board available from smaller trees could make possible a substantial expansion of the local furniture industry.

PEOPLE

More tragic than the erosion, the floods, or the lack of trees are the living conditions of these people who attempt to farm the lands which should be forested. The fallacy of such land use is readily evident in their housing, income, and diet: the poorest in the islands. The destructive nature of farming these areas is evident in the need to shift areas of cultivation from place to place each year to "rest" the soil. The people in these areas are painfully aware of the limitations of their environment. Most of them would readily accept any alternative which promised better immediate and future income.

The conservation of soil and water and the production of timber in these areas will require that current uses of these lands disappear almost completely. However, considering all areas together, the present population in these areas may not greatly exceed that which might eventually be supported by a fully developed forest economy. Abandonment of active farming has already greatly reduced the population in most of these areas. Thus, whereas some families might have to move to adjacent lands in valleys and elsewhere, the problem of population adjustment might be met without large scale emigration.

A problem which affects us all is the lack of naturally forested areas suited for outdoor recreation. Many attractive locations in the islands are not suitable for development as recreation areas because of deforestation. This not only limits the recreation activities of the local population but limits tourism development and income as well.

MONEY

The important problems arising from misuse of forest lands and products have been described in terms of soil, water, timber, and people. Each of these problems represents an economic loss to the islands. All of us who live in this area share this economic burden which might be materially reduced. Some of this loss is intangible, difficult to evaluate in monetary terms, and thus it unfortunately tends to escape notice. The following examples throw light on the money values involved in these problems. These examples are all linked to improper use of lands suited only for forest:

1. In the Guayabal watershed sediment in the rivers coming from these lands so filled the $2,000,000 Guayabal reservoir in 34 years that another $2,000,000 had to be spent merely to raise the dam to a level that would restore the original capacity. This represents a loss of almost $60,000, or $4.00 per acre annually for the area irrigated. The real problem, sedimentation, remains unsolved, and will continue to rob the reservoir of its capacity. Soil losses from the cultivation of steep lands needing forest protection is the primary cause for serious sedimentation damage to about 1500 acres of extremely valuable cane lands and to highways in the lower Añasco valley in western Puerto Rico.
2. Excessive surface runoff from steep slopes causes rivers to overflow their banks, claiming several lives each year in Puerto Rico, cutting away precious alluvial soil along streambanks, subjecting thousands of acres of the most valuable lands of Puerto Rico to crop losses due to flood damage, and each year causing heavy damage to roads, communication lines, and towns along the lower river courses.
3. Water scarcity during the dry season, a natural result of the excessive surface runoff during rainy periods, has been accentuated materially by the removal of forest from steep lands. At present it leads to water rationing in some cities, it limits the areas suitable for new industries, it is partially responsible for the expenditure of millions of dollars on large artificial storage facilities for irrigation, hydroelectric power and domestic use; and in the Virgin Islands it has eliminated surface water as reliable source for cities.
4. The local scarcity of timber resulting from misuse of the forest lands and proproducts has made necessary the importation of nearly all lumber and many other products. The value of net imports of wood and wood products during fiscal year 1955-56 was $32,700,000. Of this, a value of at least $5,800,000 could have been produced locally.
5. The harvesting and manufacture of forest products, an industry which without encroaching on lands which should be dedicated to other crops, is conservatively estimated to have an annual potential gross product of $10,000,000, and employ 2,500 people, is virtually nonexistent.
6. The cost of artificially maintaining in submarginal farming a population on lands which should be forested is composed of so many factors that it is virtually impossible to estimate. Suffice is to say that the focussing of the current level of public assistance being offered to these areas upon the conversion to a forest economy might make possible considerable progress toward that objective.

SOLUTIONS TO OUR FOREST PROBLEMS

The forest problems just described suggest that our ultimate objectives should be that at least the 524,000 acres unsuited to other crops should be covered with protective and, where practical, productive forest. The productive forests should contain trees of the species most valuable in the market and should be managed on a basis of sustained yield, providing a continuous supply of products and related employment, year after year. The trees should be efficiently harvested and fully utilized for the various products they best make. The wood should be properly dried, the products carefully manufactured, and where necessary to improve their utility, they should be treated against insect attack, decay, shrinkage, and flamability. The population dependent upon the forest land areas should be in balance with the support which can be provided continuously by forestry and related work.

The chief obstacles to progress toward these goals are the following:

1. A belief on the part of those who own or control most of the 524,000 acres that income from forestry is no greater than from farming, however destructive this may prove in the long run, or that complete lack of use, because it requires no immediate investment, is preferable to forestry.
2. A hesitation on the part of the public in general to expand public forestry in the face of the apparent difficulties in predicting the magnitude of the community benefits to be derived therefrom.

Both of these obstacles presumably could be overcome if landowners could be shown that on such lands forestry pays more than other land uses and that income is not greatly deferred. To the degree that this can be done forestry will develop "painlessly" like other attractive economic activities. To the degree that this cannot be done the public as a whole must continue to bear the burden of inadequate protection or low productivity of these lands. This burden may be gradually reduced by at least three approaches:

1. The discovery and development of new forestry practices which will be more attractive to the owners of these lands.
2. Public financial incentives for the protection of and the practice of forestry on these lands.
3. Outright public acquisition, protection, management of these lands as public forests.

Each of these approaches might be warranted under certain conditions, but in general they are in descending order of desirability. The great hope lies in forest research. Through research two-thirds of this area, some 380,000 acres, might be made permanently self supporting. On critical areas where this is not possible and where the land would otherwise be cultivated, financial incentive for the protection of soil and water resources might prove desirable, or at the very least, a discontinuation of incentive payments for non-conserving crops. In large blocks of such lands public acquisition will probably be the best long-run solution.

PROGRESS TO DATE

The Commonwealth and Federal government in Puerto Rico and the Virgin Islands Corporation have made progress toward this goal of good forestry. In Puerto Rico, some 90,000 acres have been set aside or purchased as public forest. These lands have been protected, bare areas have been planted, worthless trees have been removed, and administrative facilities, roads, and recreation areas, have been constructed within them. Research on the best forestry practices has been in progress for many years.

In both Puerto Rico and the Virgin Islands a continuous public campaign is in progress to encourage reforestation and forest conservation on private lands. This campaign involves directly the educational activities of the Agricultural Extension Service of the University of Puerto Rico and the Virgin Is-

lands Experiment Station; technical assistance by the Puerto Rico Division of Forests, the Virgin Islands Forestry Program, the Forest Service, and the Soil Conservation Service; tax relief by the Commonwealth; free planting stock by the Puerto Rico Division of Forests, the Forest Service, and the Virgin Islands Forestry Program; incentive payments for tree planting by the Agricultural Stabilization and Conservation Agency of the U. S. Department of Agriculture; and research by the Forest Service.

Concrete results from the forestry programs are evident chiefly on the public lands. Elsewhere hardly an acre of forest is cut over with any concern for future productivity. Tree planting on private lands is at a rate which, if mature plantations are harvested promptly, will maintain tree-covered less than five percent of the lands needing reforestation. The growing stock in private forests is repeatedly impoverished by frequent removal of the more valuable trees.

THE PROGRAM OF THE RESEARCH CENTER

The research organization now known as the Tropical Forest Research Center, one of 68 maintained by the Forest Service of the United States Department of Agriculture, has operated since 1939. Its past program has included an appraisal of a large amount of forest planting work done prior to its establishment, investigation of methods for production of planting stock, the introduction and selection of trees for planting under different environment conditions, studies of practices for bettering existing forests, and investigations as to the machinability of local woods. As a result there are prospects for reducing the costs of planting stock, adapted good quality tree species are known for most forest sites, and many of the tree species in local forests have been appraised as to their potential rate of productivity and their utility for cabinet work. This information is valuable but with few exceptions it is not adequate to convince the landowner that forestry is good business.

The present research program of the Center is directed toward three objectives:

1. The development of economically attractive forest crops for the most promising areas of forest lands. This involves coordinated testing of both the production and the utilization of such crops.
2. The raising of the value of existing trees and incidentally of future forest production by the development of new uses for local woods, better methods for their manufacture, and by increasing their service life through preservative treatment.
3. The discovery of economically attractive techniques for the conversion of existing run-down forests into highly productive stands by favoring the best available trees.

New tree crops are being tested on all of the extensive forest land problem areas. Emphasis is upon rapid-growing, relatively short-rotation crops. New uses are being tested with the more common sawtimber species, and as many as 50 tree species may become much more valuable for fence posts as a result of preservation tests in progress. The conversion of existing forest into highly productive stands, a large-scale, long-range study, is entering its third year of systematic treatment on a 7,000-acre pilot management area within the Luquillo Experimental Forest. In prospect are timber supplies adequate for small wood-using industries.

In addition to its research program, the Center has entered into related activities which assist in putting to use the results of research. These include cooperative programs with the Commonwealth of Puerto Rico for the production of forest tree nursery stock for free distribution and for technical forestry assistance to farmers; demonstration of good public forest management in the Luquillo Forest and related technical advice to the

Puerto Rico Division of Forests, Fisheries, and Wildlife; a cooperative program with the Virgin Islands Corporation for nursery stock production, technical forestry assistance, sawmilling, and preservative treatment; and the training of foreign forestry students, both individually and in formal short courses for groups.

The program of the Center in 1957, as in previous years, gave more emphasis to the production of forests than to their utilization. Nevertheless, the forest management research project was without a professional leader throughout the year, a situation which has prevailed for 30 months. For this reason only a limited amount of new research in forest management could begin. However, 137 tests already in progress were completed.

This report presents research highlights which will be described more fully in subsequent publications of the Center.

FOREST MANAGEMENT RESEARCH

The field of forest management research covers all aspects of the production of timber. The program of the Center includes the following active projects within this field:

1. *Dendrology:* The identification of the trees of Puerto Rico and the Virgin Islands and the development of aids for their identification.
2. *Seed studies:* The determination of how to select, collect, store, test and sow forest tree seed for propagation.
3. *Nursery studies:* The development of better techniques for the production of forest tree planting stock.
4. *Planting studies:* The development of methods for the selection of forest tree species to plant, planting, and care for forest plantations.
5. *Silvics:* The determination of the effects of soil, climate, and plant competition upon the regeneration and development of trees and forests.
6. *Stand Improvement:* The determination of how best to improve existing forests.

The research work on each of these projects is oriented toward one or more of the three objectives already described. The work in dendrology is directed toward a better understanding of forest trees by the public. The seed, nursery, and planting studies are concerned with the reforestation of the forest lands already described. The studies of silvics and stand improvement both concern the betterment of remaining forests on lands unsuited for other crops.

Dendrology

The Center moved closer to the completion of a semi-popular book "Common Trees of Puerto Rico and Virgin Islands", a project of many years. The manuscript describing 250 tree species with text and plates, has been drafted by Dr. Elbert L. Little Jr., Dendrologist for the Forest Service. The draft in English was approved by a board of review during the year. Descriptions of 200 species were translated at the Center into Spanish preparatory to publication proposed by the University of Puerto Rico.

Seed Studies

The major tree seed problems have been studied over a period of many years. Although there are some serious gaps in our knowledge other problems attracted more of the attention of the Center during the year.

Mexican cypress *(Cupressus lusitanica)* a promising tree for reforestation of steep slopes at high elevations in Puerto Rico, was subjected to a seed test. This species, exotic to the islands, bore seed in its second or third year after planting at about 3000 feet elevation in the Toro Negro Division of the Caribbean National Forest. By the sixth year a few seedilngs appeared beneath the trees. The prospect of a local seed source led to tests of seed from ten trees selected because of the natural seedling beneath them. Germination, tested in the soil, was discouraging, averaging 4 per cent and with no lot reaching

10 per cent. Testing of the adaptability of this tree will apparently have to continue to depend upon imported seed.

Nursery Studies

Forest tree planting stock has been produced in nurseries in Puerto Rico for more than 30 years. The Federal and Commonwealth governments now share the cost of a large-scale program of planting stock production and distribution for reforestation.

Casuarina *(Casuarina equisetifolia* Forst.) is the most popular tree for reforestation in Puerto Rico. It is rapid growing, adapted to poor soils, and it provides stakes, posts, and poles for tobacco barn construction and maintenance. The production of planting stock of this species has always been plagued by heavy losses in the nursery; due to low germination, insect attacks and disease, and the thinning necessary to compensate for oversowing where losses were less than expected.

Past experience had shown that for each 330-square-foot seed bed it was necessary to sow four pounds of seed (1,200,000) to obtain a good stand (40,000 seedling). In an effort to reduce early mortality and to control weeds a test was made in 1957 at the Catalina Nursery with soil fumigation, using methyl bromide. The result was a saving of 50 percent in seed.

Weeding is the most expensive nursery operation and seriously affects the cost of planting stock. The problem recently became intolerable at the Catalina Nursery due to the spread of *Ionoxalis martiana* (Zucc.) Small, a persistent weed with underground rhizomes. Here again soil fumigation with methyl bromide proved successful in 1957, killing even the rhizomes. The treated area remained weedless for 8 weeks, greatly reducing the weeding job.

Planting Studies

Studies of the adaptability of different tree species for planting were in progress in all of the potentially productive forest areas of the islands listed in Table 1, with the exception of mangrove, where reforestation is not a problem. A total of 93 studies were completed during the year. These showed the adaptability of a large number of native and exotic tree species. The results of these and many other previous studies are being compiled for the preparation of a bulletin on forest planting.

An additional 80 studies already in progress were continued through the year. Seven new tree adaptability tests were begun. The description of the work is here presented in accordance with the forest land areas listed in Table 1.

Humid Limestone Hills

This area, totalling 161,000 acres, contains more than 100,000 acres of land in northern Puerto Rico which apparently is potentially productive of timber crops. It ranges from sea level to nearly 1000 feet in elevation, with rainfall from 60 to 80 inches annually. The soil is acid but shallow, over porous limestone. Most of the area is forested but with trees which are of poor quality. The slow reaction of the natural vegetation to release cuttings and the inferior character of the tree species present suggest that better species must be introduced, probably by underplanting beneath these stands. Research in this area is in progress within the Río Abajo, Guajataca, and Cambalache Forests. Most studies are concentrated at the base of the hills on the site considered suitable for the production of large timber.

The most spectacular tree species planted so far on this site is Honduras Mahogany *(Swietenia macrophylla* King). It is well adapted to the sinkholes between the hills and on the lower slopes. Studies completed during the year showed it capable of high survival when planted or direct sown beneath light shade. The underplanted trees are of good form and free of insect attack. In well managed plantations the better trees average 9 inches in diameter at breast height after 18 years. However, the species has been found unsuited to the slopes above the valleys, and

in the sinkholes serious damage was found in a few areas after the 1956 hurricane.

Dominican mahogany *(Swietenia mahogani* Jacq*)* is another valuable timber species which is adapted to this area. It is generally slower in growth than Honduras mahogany, but the wood is considered superior. Moreover it is adapted to the upper slope of the hills, and may be established by direct seeding on this area. One plantation under study has dominant and codominant trees with an average diameter at breast height of 6 inches after 22 years.

A third species, teak *(Tectona grandis* L.*)*, grows well in the sinkholes, but not on the limestone slopes. One of the world's most useful woods, it has attained an average diameter of about 8 inches in 19 years in a well managed plantation on this site. It appears to be more windfirm than Honduras mahogany but tends to remain shorter than that species, apparently a reaction to the shallow soil.

The two mahoganies and teak may well have a permanent place in forestry in the humid limestone hills. However, the production of high grade lumber, even with these species, will require at least 40 years. Although thinnings might repay all costs well before this date, such a long-term crop is not now attractive to most landowners.

The search for short-term forest crops for this area has not yet been successful, although several tree species appear adapted to the lower slopes. *Eucalyptus kirtoniana* F. v M. and *Casuarina equisetifolia* Forst. both produce a large volume of polewood in a brief period here. However, neither of these species are valued highly at present because their chief local use is for fence posts. In the absence of preservative treatment posts of these species remain serviceable only about 30 months. A number of other tree species which have been under test on this site were classified as unsatisfactory during the year, either because of slow growth, poor form, or both. Among these are *Cordia alliodora* (R & P) Cham, *Cedrela toona* Roxb, *Andira jamaicensis* (W. Wright) Urban, *Bucida buceras* L and *Petitia domingensis* Jacq.

Dry Limestone Hills

The dry limestone hills of southwestern Puerto Rico contain an estimated 44,000 acres of land unsuited for crops other than forest. As was shown in Table 1, this area is also of doubtful productivity for timber. It is mostly covered with low scrubby forest growth of little value for its wood. Included within this area is the Guánica Forest.

Past efforts to liberate the better trees in the natural forest from competition and to introduce better tree species have tended to bear out the belief that these lands are of little value for timber production. Ucar *(Bucida buceras* L), the most prominent timber tree in the remaining forests, was found by repeated remeasurement to grow to slowly under these conditions to suggest any economic possibilities. One plantation of Dominican mahogany on a favored site in a protected valley has produced trees of 6 inches in diameter in 25 years. This growth rate, although it is more rapid than that of most of the native vegetation, does not present a favorable economic picture to the owners of most of this land. Since this area is likely to be of little value as a contributor to the timber requirements of the island, investigation within it is limited to routine observations and periodic measurements in a few stands.

The Mangroves

The magrove forests of Puerto Rico border the sea along protected coasts, bays, and estuaries. Their total area is estimated at about 10,000 acres. Nearly the entire era is forested with two tree species, white mangrove *(Laguncularia racemosa* (L) Gaerth.) and black mangrove *(Avicennia nitida* Jacq.). Both of these appear to decline in growth rate before they reach sawtimber size and thus are best suited for roundwood products

such as posts, poles, or charcoalwood. Research in this area has been carried on in the San Juan and Aguirre Forests.

Past studies have shown that the best method to harvest our mangrove forest is by clear cutting. Partial cutting in 20 year-old stands, leaving the best trees to grow for the future, showed that the rates of growth of these trees can be accelerated thereby. However, the more open forests resulting are susceptible to wind damage which can completely nullify these benefits. Since most of the forests are composed of trees of nearly the same size, most of them reach maturity at about the same time and clear cutting is thus practical. Tests have shown that a new forest will start naturally within two years after clear cutting if a seed source is close at hand.

During 1957 a study was completed which determined the probable quality of the stands following clear cutting. The large number of crooked trees of sprout origin common in mangrove forests suggested that stands coming up after clear cutting would be mostly of sprout origin and thus poorly formed. A study in a white mangrove forest showed in 1957, however, that new tree seedling also appear in the regeneration and after 5 years exceed the height of the sprouts.

Present knowledge of the mangrove forest seems adequate for intensification in management as soon as the products of the forest become sufficiently valuable to warrant this. One prospect is in the treatment of mangrove posts with preservatives. The work of the Center toward this end is described elsewhere in this report.

The Shallows Loams of the Mountains

The steep shallow loam areas in the mountains, where some 166,000 acres are considered unsuited for crops other than small timber, are critical for soil and water conservation. Virtually all of this area has at one time or another been cleared for farming, and most of it is still deforested. Elevation ranges from 500 to 2500 feet and rainfall from 50 to 90 inches annually. This area has been slighted in the past research program of the enter because of the availability of larger publicly-controlled forest areas for research elsewhere. However, plans were drawn up during the year to begin extensive testing of new crops for this area.

In preparation for full-scale testing 12 species in 6 sites within this area, preliminary trials were made near Aibonito in late 1957. The species chosen were believed to be of rapid growth and merchandable as posts and round timbers. At the close of the year survival was inconclusive. However, the direct use of cuttings on the field did not give more than 50 percent survival, even for such well-known sprouters as *Spondias mombin* L., *Ficus laevigata* Vahl, *Erythrina poeppigiana* (Walp) P. F. Cook, and *Castills elastica* Cerb.

The Deep Clays of the Mountains

The steep clay areas in the mountains, because of greater soil depth, are considered more suited to large timber production than the shallow loam soils. In all, some 41,000 acres are in this area, scattered throughout the mountain region, mostly between 1,000 and 2,500 feet elevation. Rainfall ranges from 80 to 130 inches annually. Part of this area is forested, notably within the Luquillo, Guavate, and Toro Negro forests and in parts of the coffee region on the western mountains. Nevertheless reforestation is needed on a large area subject to shifting cultivation.

Past studies have shown that Honduras mahogany *(Swietenia macrophylla King)*, is adapted to the lower elevations within this area although on wet soils it is not windfirm. This species normally is not used for reforestation because of insect attack *(Hypsiphyla grandella)* Zeller), but it can be effectively underplanted beneath existing forests. Above 1,500 feet elevation reforestation has proven successful with *Eucalyptus robusta* J. E. Smith and *E. kirtoniana* F.v.M. The pros-

pect of heavy hurricane losses with mahogany, and the lack of a steady large market for the eucalyptus has limited their use primarily to public forest areas. Although a few of the mahogany plantations, at 25 to 30 years of age, are producing lumber from thinnings, accelerated planting of this species must await more complete understanding of the capacity of the tree to withstand winds. Eucalyptus, at 12 to 20 years has become useful for underground piling.

A most impressive recent introduction on this area is Mexican cypress *(Cupressus lusitanica* Mill), a tree which elsewhere is used for Christmas trees and for lumber. This tree at elevations of 2,500 feet or more has proven capable of growth in diameter exceeding that of eucalyptus (more than 1 inch per year for 10 years). However, it lacks windfirmness on certain sites. Examinations during the past year suggest that rocky soils in areas with relatively low rainfall (the shallow loam area) may prove best for this species.

Other trees under observation in test plantings in this area include additional eucalyptus, roble *(Tabebuia heterophylla* (DC) Britton), cedro macho *(Hyeronima clusioides* (Tul) Briseb.), jaguilla *(Magnolia portoricensis* Bello), and guaragua *(Guarea trichilioides* L.) Some of these are more impressive than others but none have yet been conclusively shown as attractive economically as mahogany or eucalyptus in this area. Roble, because of its adaptability to poor soils, has been used to reforest areas too unfavorable for other valuable tree species.

The Sandy Loams of the Mountains

The steeper slopes in the sandy loam areas near Utuado and Jayuya make up not less than 25,000 acres which are unsuited for crops other than forest. Elevation ranges from 800 to 2500 feet and precipitation from 70 to 100 inches anually. This area is especially critical for soil and water conservation. The soil is loose and erodes rapidly when exposed. On the other hand, if protected, the soil is sufficiently porous to absorb and store tremendous amounts of water. Most of this area has been deforested and is subject to shifting cultivation for tobacco and minor crops.

The climate and soil of this area are both favorable for tree growth. Nevertheless, here again no economically attractive tree crop has been developed. During 1957 tests began with Mexican cypress *(Cupressus lusitanica* Mill.). The tree survived planting but nothing is yet known regarding its rate of development and windfirmness. Future tests here are to include pines.

The Laterite Soils

The laterite soils derived from serpentine rock in the western mountains, found on some 28,000 acres, have mostly been farmed and then abandoned as unsuited for cropping. They range in elevation from 800 to 2500 feet, and rainfall ranges from 80 to 110 inches anually. Research within this area has been carried on in the Maricao Forest.

Past efforts to reforest this area with valuable tree species have generally failed. Eucalyptus has grown well on only a few favored locations. More than 20 species of this group have been tested. Maria *(Calophyllum brasiliense* Camb) has survived well after direct seeding, but only on the more protected sites are the trees well formed.

Mexican cypress *(Cupressus lusitanica* Mill) has recently shown promise here as a possible Christmas tree. Tree growth is slower here than elsewhere but the branches are firmer and more suitable as Christmas trees. In a plantation 7 years old the trees average 2 inches in diameter and 14 feet in height. Christmas tree size was reached in 4 years.

Kauri pine *(Agathis australis) Salisb.)* another tree species remeasured in this area during the year, has proven to be one of the most vigorous appearing trees tested. At 20 years of age these trees average 10 inches in diameter.

The most spectacular result of forest research in this area is the apparent success of tests with slash pine *(Pinus elliotti* Eugelm*)*. Earlier tests with six species of pines on this site failed. However, inoculation of slash pine with mycorrhizae, reported previously, has continued to show promising results. By the end of the year, 30 months after inoculation, almost 90 percent of the treated trees were vigorous, deep green in color, and they had grown an average of 16 inches in height. None of the untreated seedlings were vigorous, 25 percent of them had died, and those remaining had grown only 3 inches in height. These results, while still preliminary, suggest similar tests with inoculated pines in more favorable areas.

The laterite soil area is still one of the least promising, even for forestry. Nevertheless, observations in existing forest plantations and the search for new, more promising tree species will continue.

The Excessively Rainy Areas

The upper slopes of the Luquillo Mountains, the Sierra de Cayey, and the highest ridges of the Cordillera Central are, because of excessive rainfall, of value only for trees. The soil in this area, highly leached heavy clays, are infertile. Even the natural forest is poor, its trees small in size and crooked. Almost all of the 19,000 acres in this area are forested.

The poverty of the natural forest in this area, the high rainfall, and the unsuitability of the soil for other crops all suggest that protection is probably the highest value of the forest growth here. Attempts to introduce eucalyptus, cypress, and bamboo all have failed or suggest the need for special care such as the application of fertilizers. No further research is in progress here.

Steep Slopes in the Virgin Islands

The steeper slopes of the mountains in St. Croix, St. Thomas, and St. John are unsuited for farming. Excluding the National Park in St. John, there are not less than 30,000 acres of land in the three islands which are suited only for forest. This area ranges in elevation from near sea level to about 1,500 feet, and rainfall ranges from 20 to 60 inches anually. Nearly the entire area is covered with woody growth which is little used. On those areas capable of producing wood products, the most valuable type of forest crop would appear to be attractive woods which might provide maximum employment in the manufacture of furniture and novelty items for the tourist trade. Smaller trees might best serve for posts, poles, and charcoal for local consumption.

The presence in the islands of Dominican mahogany *(Swietenia mahogany* Jacq.), its apparent adaptability even on some of the least favorable lands, and the quality of its wood for the purpose cited all led to the centering for forestry work in the islands around this species. Honduras mahogany *(Swietenia macrophylla* King) a tree which in Puerto Rico grows more rapidly and straighter than Dominican mahogany, is also found in St. Croix. Tests have shown it adapted to at least the more humid forest lands of that Island. Both have proven suited for underplanting in narrow cleared lines through the existing forest.

With such valuable tree species already at hand and obviously adapted to at least certain areas of forest lands, the first problem appeared to be the development of a cheap method to establish them. Experience in Puerto Rico had shown the necessity of keeping a ball of earth around the roots of Dominican mahogany planting stock to obtain high survival. Honduras mahogany, on the other hand, normally survives bare-root planting on humid sites. Tests begun in St. Croix in 1955 have shown that in favorable years satisfactory survival of both species is possible with bare-root planting if the stock is of top quality. Under these conditions even broadcasting and direct seeding can be successful. During dry years, on the other hand, Dominican mahogany stock must be

potted, and bare-rooted stock of Honduras mahogany gives low survival except on the most humid areas. In such periods direct seeding and broadcasting generally fail since such germination as takes place precedes the dry season by only two or three months.

The ideal period for planting in wet years is at the beginning of the rainy season in May, in order to provide a long growing season before the first drought. However, in dry years the rainy season may begin 5 months later leaving only 3 months in which to plant. Trees set out so shortly before the following dry season suffer heavy mortality. Because of the impossibility of predicting the weather, present practice is to plant stock rather than to direct seed, to plant all Dominican mahogany with a ball of earth, and to confine Honduras mahogany to the wetter areas.

In spite of the tropical value and apparent adaptability of the mahoganies in the Virgin Islands, it is desirable to use more than just these two species in forestry there. Dominican mahogany is not rapid growing, has an unfortunate tendency to be limby, and in Puerto Rico has recently become subject to a serious disease of undetermined origin. Honduras mahogany is generally considered to produce a less valuable wood than Dominican mahogany, and in some areas of Puerto Rico it has proven susceptible to windthrow, a serious drawback in the hurricane belt.

Teak *(Tectona grandis* L.*)* was introduced into St. Croix more than a decade ago but only a few trees, used as ornamentals, have remained. It produces a wood such as needed in the islands for the purposes already described. Tests showed that it was more practical to ship in teak planting stock from Puerto Rico than to produce it locally where small-scale production is costly and germination is sporadic due to the dry climate. Test plantings show it capable of high survival in St. Croix, but weeding of young plantings is a serious problem requiring attention at least twice during the first year. A 1957 test of weed control with herbicides, using sodium TCA and CMU, was inconclusive because of an indicated inhibiting effect upon the growth of teak.

Other species which are apparently adapted to the islands and deserve consideration in future research are tibet *(Albizzia lebbek* (L) Benth.) *Maria (Calophylum brasiliense* Camb.) and roble *(Tabebuia heterophylla* (DC) Britton). The first of these is an exotic tree which has invaded pastures and roadsides. Its wood is attractive. Maria, almost entirely absent from the islands is being tested as a fence-row tree and windbreak.

Silvics

The research of the Center in the field of silvics has in the past been concerned with the classification of different types of forest and the description of the climatic and soil conditions which produce them. The growth of trees within a large variety of forest has been measured over a period of years to determine its relationship to visible environment factors such as light, competition, soil, and topography.

Growth of Yagrumo

Interest in Yagrumo hembra *(Cecropia peltata* L) has arisen from its use for excelsior in Puerto Rico and from other prospective uses of the wood. Since the future importance of yagrumo is as dependent upon supply as it is upon demand, studies of its production have begun. A first step was an analysis of existing growth records for this species.

Yagrumo hembra is generally considered a very fast growing tree. This reputation is earned by its performance on areas recently cut over, where light and organic matter are plentiful and where competition with other trees is a minor factor. Growth of yagrumo in dense virgin forests, on the other hand, was reported a year ago to be nothing out-

standing. To provide information as to what might be expected in plantations managed at a density intermediate between these extremes 8- to 10-year growth records were summarized from four plots covering 3 acres in the tabonuco type of the Luquillo Forest. This area, on deep clay soil, and receiving at least 100 inches of precipitation annually, is typical of the area where this tree occurs in Puerto Rico. The plots measured are of mixed composition, and contain 50 trees of yagrumo. The density of these forests, ranging from 80 to 100 square feet of basal area per acre, lies near the upper edge of that which other studies have indicated should be maintained under good management. The records are summarized in Table 2.

TABLE 2 GROWTH OF YAGRUMO HEMBRA ON CUTOVER STANDS

Initial Crown Position	Number of Trees	Average Initial DBH	Average Diameter Growth in Ten Years
	No.	Inches	Inches
Dominant	5	10.0	3.1
Codominant	6	11.0	1.9
Intermediate	36	3.3	3.3
Suppressed	3	1.9	3.7

These data, although they are not as strong as might be desired, suggest certain characteristics of yagrumo growth. Growth in all crown positions apparently can be rapid, in spite of the general belief that the tree is shade tolerant. Rapid growth can also be sustained to diameters as large as 10 inches if trees are given adequate growing space. Of these trees the most rapid growing individual, an intermediate of 3.4 inches d.b.h. at the beginning of the period, grew 6.2 inches in diameter in 8 years. The most spectacular growth rate of all, that of young trees in the open such as would characterize early plantation development, is not shown in these plots.

Stand Improvement

Investigation of techniques for and results of the improvement of existing forests have of necessity been confined to the small areas where these remain. All work of this nature has been concentrated within the public forests. As a beginning the effects of different types and degrees of cutting upon the growth of the remaining forest were studied, chiefly on small controlled plots. These first studies showed the approximate extremes of desirable stand density and the relative response to treatment of different trees within the forest. Synthesis of the results of a number of these small studies provided a basic technique for stand improvement which has been and is being applied widely upon the public forests.

Pilot Management Study

The present technique for forest improvement, although it appears to avoid the most serious pitfalls of mismanagement, was put to use before it had been evaluated in terms other than growth response. In order to test its practicability on a large scale and as a long-range policy it is being applied in a pilot management study on about 7,000 acres on the north slope of the Luquillo Moutains, the largest natural forest within Puerto Rico. The results of this study should, in general

terms, be applicable to all areas of natural forest in Puerto Rico with the exception of those which prove unsuitable for timber production.

Within the pilot management area an intensive forest management program has been undertaken. The area is divided into 46 compartments for continuous, systematic treatment on a 5-year cycle, directed toward sustained timber yield and forest employment. Mature timber is sold and undesirable trees are killed. Road construction to make all of the area accessible is contemplated. At the end of 1957, after two years of operation more than 2,300 acres had been subjected to an improvement cutting. In anticipation of better future markets for timber the least accessible areas were treated first, yet during these first two years 232,000 board feet of timber were sold for a stumpage value of about $5,000.

The chief expense in forest improvement is the elimination of trees of no present or prospective value. Experience in 1956 showed felling to be too expensive and girdling to kill too slowly. A major improvement resulting from investigation during the year was the use of the arboricide 2, 4, 5-T (4 pounds acid equivalent per gallon) as a 5 percent solution in diesel oil. Applied in shallow frills, consisting of a continuous row of axe cuts around the tree, this solution has proven very effective, killing some trees within four weeks during the most active growing season. Nearly all trees are dead after one year. Persistent exceptions are mango *(Mangifera indica* L.) and pomarrosa *(Eugenia jambos* L*)*. The use of poison has reduced labor costs by 75% to about one man-day per acre.

The treatment itself is in accordance with the following general policy:

A. *Stand Condition Requiring Treatment*

1. Canopy trees average 3.6" d.b.h. or more.
2. Crowns of trees mostly in contact.

B. *Degree of Opening Permitted*

1. Trees with average of 6 feet of crown freedom on the sides.
2. No openings to the forest floor larger than 25 feet unless caused by removal of a single tree.

C. *Trees to be Removed*

Excess trees, as defined by B, above, in the following classes, removing first those nearest the top of the list. 1/

1. Dying, seriously diseased or insect infected.
2. Inferior species (any not included in 3, 4, or 5 below).
3. Pole species 10" + d.b.h.
4. Second class sawtimber species 16" + d.b.h.
5. First class sawtimber species 21" + d.b.h.
6. Remaining trees without a sound, straight butt section of at least 8½ feet in length.
7. Remaining trees with poor vigor or seriously broken crown.
8. Remaining trees still in excess of desired density (Smallest and poorest first).

   a Pole species.
   b. Second class sawtimber species.
   c. First class sawtimber species.

Detailed sampling of the results of this treatment is being made in four compartments representing distinct site and stand conditions. One hundred fifth-acre permanent plots are being established and measured in each area. Preliminary data from the first of these areas were collected and summarized in 1957. This area ranges from 600 to 1200 feet above sea level. Precipita-

1/ The classification of tree species as first class, second class or poles, not shown here, is based upon past research into the characteristics of both tree and its wood.

tion is about 90 inches annually. Soil is a deep acid clay. The forest is secondary with no trees mature for sawtimber at present.

The stand density in this compartment was reduced nearly half, from 63 to 34 square feet of basal area per acre. The volume was reduced from 430 to 308 cubic feet per acre. The composition of the forest was improved by leaving better tree species than those cut. Before the cutting 41 percent of the stand (basal area) was composed of desirable species. The cutting raised this percentage to 50. The release from competition resulting from the cutting increased from 79 to 99 the percent of desirable trees receiving full overhead light. Remeasurement of these plots 5 years hence will show the development of the residual stand. A second improvement cutting is scheduled for that time.

THE ELIMINATION OF UNDESIRABLE TREES

A study of peel-girdling of trees, the traditional local method, was begun in 1952 and completed during the year. In a mixed stand on the Luquillo Forest 191 trees were completely girdled by the conventional machete method, removing a broad band of bark. By the end of the first year 41 percent of the trees were dead. After 2 years 72 percent were dead; after 3 years, 82 percent; after 4 years, 84 percent, and after 5 years 89 percent. Sprouts developed below the girdles on many trees but usually died later with the tree, possibly because the remaining stand was still dense and provided heavy shade. The results proved too slow for forest improvement work which contemplates rapid response to treatment prior to the next cutting 5 years hence.

A second study was planned, to compare the double-hack girdle, frill-girdling, basal incision, basal spray, and bark spray with ammonium sulfamate and 2, 4, 5-T. A test of the double-hack girdle in 1957 showed an 80 percent kill in one year.

Response of Dominican Mahogany To Release Cutting in St. Croix

A windbreak of Dominican mahogany *(Swietenia mahogani* Jacq*)* planted in east central St. Croix during the Danish period has given rise to a nearly pure mahogany forest to the leeward covering an area of some 300 acres. This forest is composed of a few scattered large limby trees and a dense stand of young poles of 4 to 8 inches d.b.h. beneath them.

The density of these young stands suggested thinning, so in 1952 two intensities of thinning were tested in the Thomas Estate Experimental Forest. The objective was to determine that level of density which would be open enough to assure rapid growth of the best trees yet sufficiently closed to prevent excessive branching of these same trees. The initial density of the forest exceeded 100 square feet of basal area per acre. One area was thinned lightly, leaving 92 square feet, and the other heavily, leaving 58 square feet.

Observations during the subsequent 5 years showed that excessive branch formation was no problem in either area. At the end of the period the average annual diameter growth of the trees in an unthinned area was 0.10 inch; in the lightly thinned area, 0.13 inch; and in the heavily thinned area, 0.24 inch. The promptness and magnitude of the response to the heavier thinning are not the only criteria for appraising this practice, but the results were so marked that thinning of this character is being done on a systematic basis on an 100-acre area in the Thomas Estate Experimental Forest.

Growth In Cutover Colorado Type Forest

The forest of the excessively rainy areas in Puerto Rico has been designated the Colorado type because of the dominance of palo colorado *(Cyrilla racemiflora* L) in many areas within it. This forest type, composed chiefly of malformed trees, appeared at one time to be an area where silvicultural treatment of

the forest would result in marked improvement in composition and quality. Previous reports on studies on the Luquillo Mountains have shown the extremely slow growth of even the dominant trees in virgin stands of this forest, suggesting that some may be well over 1000 years of age.

The growth rate of trees in virgin stands, while of scientific interest, is not a good basis for predicting what to expect in forests under management where the better trees have been provided with growing space by the removal of less desirable competitors. Thus a well balanced stand was subjected to an improvement cutting in 1947 and the results were observed and measured during the subsequent 10 years. The cutting removed all trees of more than 20 inches, d.b.h. and left a basal area of about 80 square feet per acre. The better trees were liberated from suppression.

No espectacular response to this treatment has been seen. The crowns of the trees, many of which were small or narrow due to previous suppression, did not increase rapidly in size in response to the additional light. The forest now appears about as open as it did at the time of cutting. There is no visible sign of new tree seedling. Instead, soil beneath the larger openings has become covered with such dense stands of razor grass *Scleria* sp.) that the future prospects for natural regeneration are not favorable.

The average diameter growth rate of the dominant and codominant trees during the 10 years after treatment was only 0.06 inch per year, about the same in the virgin forest. Thus the native vegetation here appears to be almost non productive. It is very valuable, however for the conservation of soil and water resources in these rainy areas.

FOREST UTILIZATION RESEARCH

It was not until 1954 that a full-time technician was assigned to forest utilization research. Previous to this time investigations in this field were limited to a few preliminary tests of preservative treatment. The research program includes the following active projects within this field:

1. *Machining of wood:* The determination of the suitability of native woods for machining with saws, planes and other woodworking tools and of techniques for overcoming any difficulties encountered.

2. *Preservative treatment:* The adaptation and development of methods to increase the durability of wood and wood products exposed to deterioration from fungi, insects, and marine borers.

3. *Air seasoning of lumber:* The development of techniques for rapid air seasoning of native woods with a minimum of degrade.

4. *Charcoal production:* The adaptation of practical techniques of charcoal manufacture developed elswhere to the utilization of local low-grade wood.

The research in each of these projects is directed toward increased utility and value of forest products. Such increased value will constitute a direct economic gain and also will make more attractive the production of forest products locally with all its attendant benefits in terms of conservation.

Machining Of Wood

During 1956 tests were made of the 62 most common native and exotic timbers to determine their machining characteristics. The manuscript describing the results of these tests, originally prepared for a technical bulletin, is being reworked by F. R. Longwood in more popular style for more general use. Another manuscript by the same author describing the characteristics and uses of 75 timbers of the Caribbean region has now passed review and is in the process of publication.

No additional machining tests were made during 1957.

Preservative Treatment

Preliminary efforts were made years ago to determine the service life of fence posts, treated and untreated. Re-examinations of some of these service tests during the year

showed that cold-soaking with pentachlorephenol produced posts of several species which have endured exposure on the north coast and in the central mountains for more than 5 years, about double the expected service life without treatment. Since these posts are still sound, observations will continue. A test of eucalyptus, treated with carbolineum by the hot-and-cold bath method showed posts on the north coast and interior to be sound after 7 years, more than double the life of untreated posts.

The development of post treatment as a practical enterprise requires a more comprehensive study of the absorption and penetration of different preservatives by native post species and of their subsequent service life. In view of an estimated potential market of 830,000 treated posts (20-year service life) the preparation for this study was the main project in forest utilization research during the year. An experimental hot-and-cold bath treating plant was constructed at the Center. The two tanks are 4.5 feet deep, 4 feet wide, and 8 feet long. The hot-bath tank is equipped with eight 5000-watt inmersion heaters. The first study plan for use of the plant calls for the testing of 50 post species by the hot-and-cold bath and cold-soaking processes with both creosote and pentachlorophenol. By the end of the year about 300 test posts had been cut and peeled for drying and treatment.

The Center cooperated with the Division of Forests, Fisheries and Wildlife of the Commonwealth in preparing specifications for an experimental pressure treating plant to be used jointly by the Division and the Center. Studies of pressure treatment will develop methods for better use of existing facilities for this process and may show a justification for additional commercial plants for the treatment of local or imported wood.

Air Seasoning Of Lumber

The lumber of 62 common local timbers was dried for machining tests in 1955 and 1956. Preliminary information upon rate of air seasoning and degrade were collected at that time. These data are in the process of publication.

During 1957, as a result of an inquiry from a furniture manufacturer, the drying rate and degrade during seasoning of Colombian cedro macho *(Carapa guianensis* Aubl.*)* were studied. It was found that material arriving in Puerto Rico with a moisture content of 44 percent could by proper piling be dried to 21 percent moisture content in 49 days. This test was made in October and November.

The equilibrium moisture content at San Juan, based on yearly weather records, was found to range from 14.5 to 17 percent. The driest period is during February, March, and April, and the wettest during September and October.

Tests were made on 47 woods comparing the moisture content readings obtained with the resistant-type electrical moisture meter with those obtained by the standard oven-dry method. The results of this test have not been summarized, but in general the electrical moisture meter gave readings from 2 to 5 percent higher than those obtained by the oven-dry method at moisture contents of about 16 percent.

Charcoal Production

The charcoal market for domestic use has increased greatly in the United States in the last few years. During this year four separated interests explored the possibility of manufacturing charcoal in Puerto Rico and shipping it to the States. Our denser woods are well suited to charcoal manufacture, and the yield and quality for charcoal should be better than that obtained from the less-dense woods in the States. Samples of charcoal produced by the old-fashioned pit method were sent by the Center to the interested parties and to the Forest Products Laboratory for chemical and briquetting tests. In all cases the samples proved satisfactory. The Center obtained plans for the construction of a modern charcoal kiln in Puerto Ri-

co to be constructed by the Commonwealth Division of forests for joint experimental use.

COOPERATIVE FORESTRY AND TECHNICAL ASSISTANCE

The work of the Center which is classified as strictly research terminates with the completion of the studies and the presentation of their results in a form understandable to the person who needs the information. The publication and distribution of research results sometimes discharges this responsibility. However, effective prompt application of what is known requires demonstration, direct advice, and in some cases financial assistance. The Center has been active in all of these ways to improve forest production and utilization in Puerto Rico and the Virgin Islands. Specific projects of this nature are as follows:

1. Cooperative production and distribution forest planting stock.
2. Cooperative forest management.
3. Demonstration of public forest administration.
4. Technical assistance to processors and users of forest products.
5. The Virgin Islands forestry program.

The accomplishments of all of these projects have been greater than in past years.

Planting Stock

As in previous years, the Forest Service cooperated during 1957 in the production and distribution of forest planting stock to private land-owners. The Forest Service made available an allotment of $25,000 for Fiscal Year 1957 share with the Commonwealth Division of Forests up to 50 percent of the cost of this program. During that fiscal year a total of 435,000 trees were produced and distributed by this program.

Cooperative Forest Management

A new program of technical assistance, termed "Cooperative Forest Management", was inaugurated during Fiscal Year 1957, under a cooperative agreement between the Forest Service and the Department of Agriculture and Commerce of Puerto Rico. Under this agreement a federal allotment of $8,500 was made available to the Commonwealth to share the costs of technical forestry assistance to landowners. A farm forester was appointed by the Commonwealth and during the first year some 200 requests for such assistance were fulfilled. A separate study by the Center during the year showed that tree distribution to farmers without prior inspection of the land, attention at the time of planting, and follow-up to assure subsequent care, all by a trained forester, generally did not result in a successful planting. The cooperative forest management program provided that service in 8 municipalities where tree planting is most important. An encouraging result was a survival check which showed an average of 71 percent during 1957, in spite of one of the driest years on record.

A separate but related program of forest planting on private lands was encouraged directly by the Center in areas of Puerto Rico where tree planting is desirable but has not been done in the past. Eleven farmers were selected for the establishment of demonstration woodlots. In the selection a special effort was made to find farmers whose interest in trees appeared genuine. Only one-half acre per farm was set as a goal. In spite of special care in handling the stock for these plantings, technical assistance at the time of planting, and follow-up, only two of the plantations were successful. The conclusion reached was that until a good forest cash crop on a short rotation can be developed for these areas farmer interest will not be adequate to carry out all of the necessary steps to assure reforestation. At present the only area where this favorable situation exists is in the tobacco region where the Cooperative Forest Management program has concentrated its efforts, and where there is a large demand for stakes and poles for tobacco barns.

Public Forest Administration

The Caribbean National Forest, of which the largest unit is now termed the Luquillo Experimental Forest, is being administered in accordance with Forest Service policies for effective land management. These policies, applied to meet local conditions, are suited for all of the public forest lands of the Island.

A plan for multiple land use within the Luquillo Division of the forest lays out specifically areas best suited for each type of use. It provides for the protection of critical watershed areas. It also provides for research in the ecology of the virgin forest, in silviculture, and in forest regeneration. It sets aside a large pilot-demonstration area for applying the results of forest research. It provides for the development of recreation resources and for the protection of wildlife.

Protection of the forest, which is a prerequisite to all other uses of the area, was systematized by a scheduled boundary patrol plan covering some 73 miles of monumented boundary. Critical watershed areas, the steepest slopes and the high ridges and peaks, are reserved from all timber cutting or other use which could jeopardize soil protection. An area of 2,100 acres of virgin forest including 4 distinct types of forest has been reserved permanently by the Chief of the Forest Service for scientific study. Research in forest improvement and in tree planting is in progress in a part of the area reserved during 1957 for this purpose. The pilot management program, described in more detail elsewhere in this report, has just completed its second year. The forest was compartmented, large-scale maps were prepared and records of investments and yields are now being kept in detail. Timber sales were coordinated with the pilot management program and procedures were simplified. Forest trails were maintained. An area of 1,500 acres is reserved for recreation. During the year plans were made for much needed expansion of recreational facilities within this are and were submitted to the Park Administration. Maps of the summer home areas were prepared and each was brought up to standard as regards maintenance of improvements.

Direct liaison with the Commonwealth Division of Forests, Fisheries and Wildlife in the field of forest administration took the form of participation in three joint training sessions for rangers and guards, three interforest visits by the field men, the training of two staff men during the spring course for foreign students, and provision of three months of summer forestry work for a college graduate who then took employment with the Division.

Technical Assistance To Processors And Users Of Forest Products

Two circumstances have made technical assistance to processors and users for forest products in Puerto Rico and the Virgin Islands nearly as important as research in this field. The first is the lag between local practice and progressive development already proven elsewhere and apparently adaptable to local conditions. Examples are the use of proper seasoning methods, efficient plant layout, and use of the best machine for each job. The second circumstance is the great impetus given to all industrial development in Puerto Rico by the Commonwealth government. The Center was active in 1957 both in advising existing processors and users of wood and in consulting with industrialists considering establishment of new industries here.

The appearance of the article by the Center on "Industrial Wood Use in Puerto Rico" in 1956 (Caribbean Forester 16:64-97) and a subsequent study of forest utilization made cooperatively by the Puerto Rico Industrial Development Company and the Center, set the stage for a flood of inquiries concerning wood utilization, most of which have reached the Center through the Development Company.

Initial inquiries about wood utilization usually concern quantities available. To provide all available information of this nature the Center summarized by key species the data from the 1948 cruise of the Luquillo Forest and from the Commonwealth forest inventory of 1948-1952. While incomplete and not up to-date, these data were used in 1957 to service twelve inquiries received from the Development Company and other sources. These inquiries concerned a variety of products, including airplane models, millwork, furniture, charcoal, veneers, excelsior, coat hangers, novelties, shoe lasts, and particle board.

The most spectacular result from the technical assistance of the Center in this field during the year was the development of a market for a tree species heretofore considered inferior. Tests of material supplied by the Center showed that yagrumo hembra *(Cecropia peltata* L*)* is suitable as an excelsior for bonding with cement to form an insulating and structural board. The result has been the construction of a plant, now nearing completion, by the Insuldyne Corporation capable of consuming 10,000 cords of wood per year. It is expected that other local woods will prove suitable for excelsior also, thus providing a market for several species of trees.

Subsidiary to the Insuldyne Corporation is the J. Diener Lumber Company with a new sawmill and a demand for mixed hardwood sawtimber for pallets and crates. Preliminary negotiations with this company indicate a willingness to try harvesting mixed species as they occur in the forest, a situation which should make logging much more economical than in the past.

Frequent inquiries have concerned the moisture content of native or imported lumber. Use by the Center of a moisture meter has made possible valuable service in this field. Some of our cooperators are obtaining their own equipment for this purpose.

The Virgin Islands Program

Under a cooperative agreement with the Virgin Islands Corporation the Center conducts a broad forestry program, at Corporation expense, in the Virgin Islands. The objective of the program is to encourage better use of forest lands and forest products. The program is composed of two main projects: forest land improvement, and logging and milling. The work is centered on but not confined to the island of St. Croix.

Forest land improvement works has consisted primarily of the introduction of mahogany *(Swietenia mahogani* Jacq and *S. macrophylla* King) into brushy areas on steep slopes. The planting stock, produced locally, is provided without charge to the landowners. The year 1957 was especially unfavorable for planting because of drought. Precipitation in St. Croix was only about one third of the normal, and most of the rain fell within a two-month period. Nevertheless some 16,000 mahogany trees were planted on approximately 50 acres during the period of September to November.

Teak has proven adapted to certain better soils in St. Croix. Some 30 acres have been planted to teak in the Thomas Estate Experimental Forest, including 8,500 trees during the past year. An additional small planting was made on private land. Both teak and mahogany are viewed as favorable woods for a novelty industry which, geared to the tourist trade, could provide a large amount of local employment.

A naturally established forest of Dominican mahogany covers some 300 acres in St. Croix, partly within the Experimental Forest. A previous improvement cutting of about 100 acres of this forest removed many trees of undesirable species. A release cutting, begun on 6 acres in 1957, is removing misshapen trees, both large and small, to favor the others.

The Virgin Islands do not bear heavy timber stands, yet the scattered old trees of mahogany and other species suited for cabinet

work are a resource which heretofore has been largely wasted for lack of facilities for logging and the manufacture of lumber. The Project provides this service at cost and is gradually building an inventory of lumber suitable for a novelty industry. Some 150 logs were sawn during 1957, mostly on a custom basis.

FORESTRY TRAINING

All of the Center's facilities and resources were again used to the fullest extent in the accomplishment of our foreign training mission. The third tropical forestry short course sponsored by the International Cooperation Administration was conducted from March 13 to May 31. This course was attended by eleven participants from ten countries from South and Central America, the West Indies, Asia, and Africa.

Students attending the regular course received some training in all phases of forestry nursery and planting, silviculture, forest management, mensuration, utilization, policy and legislation, and the organization and administration of forest services. The curriculum also included the conservation of resources allied with or dependent upon forests.

In addition to the regular course, seven other persons interested in tropical forestry visited the Center for observation or study for periods ranging from a few days to two months.

Valuable assistance, particularly during the short course, was given the Center by the Food and Agriculture Division of the United Nations and various agencies of the Commonwealth government especially the Division of Forests, Fisheries, and Wildlife of the Departmen of Agriculture and Commerce.

The Fifth Tropical Forestry Short Course

By: F. RALPH THROOP, Training Officer
U. S. Forest Service
Puerto Rico

Vast sums of money are being spent by the United States and by international agencies to assist different areas of the world to improve standards of living by providing economic means and technical know-how. Many people recognize this assistance as prompted by moral or political reasons, or both. Some question the value of such assistance, believing that it can only make the recipients dependent upon continuation of such gifts.

There can seldom be any doubt as to the moral basis of such assistance and its lasting value when the money is spent to teach and show peoples how to improve their own economic conditions through better management and utilization of their own resources. The International Cooperation Administration of the United States and the Food and Agriculture Organization of the United States are two of the important agencies administering aid of this type. One project in which they both work together is in the series of tropical forestry short courses offered at the Tropical Forest Research Center of the U. S Forest Service at Río Piedras, Puerto Rico.

The fifth tropical forestry short course was presented in the spring of 1958. Previous courses have been described in The Caribbean Forester 16 (1&2) 12-23 and 18 (1&2) 33-39. All of these courses have been considered successful in the sense that they have satisfied a need of the participants. The students have returned to their respective countries with new and different views as to how to solve their problems. The participants, instructors, and coordinators all have had their eyes opened as to the problems confronting the many countries represented. Many international friendships have resulted.

The returning participants generally will not be able to apply immediately many of their new ideas toward the solution of their local problems because of one reason or the other, but they stand better prepared to take advantage of an opportunity when it does knock. They also know where they can go to get additional technical aid when they need it. These results appear to constitute entirely satisfactory goals for short training courses of this type.

The course was under the direction of the Tropical Research Center. This agency, financed for this purpose by the International Corporation Administration, furnished most of the facilities, set up the program, and did much of the actual instruction and training. In this activity the Center was assisted by the Office of Technical Cooperation, Puerto Rico Department of State; the Division of Forests, Fisheries, and Wildlife of the Department of Agriculture and Commerce of Puerto Rico; the Soil Conservation Service and the Agricultural Stabilization and Conservation Service, both of the U. S. Department of Agriculture; and the Agricultural Extension Service of the University of Puerto Rico. These agencies provided, within their special fields of activity, instructors, training material, transportation, and technical assistance.

The bulk of the training was done by the technical officers of the Research Center, but beside these and the cooperators, three other technical people participated this year: Mr. John C. Killebrew of the Forest Products Laboratory in Madison, Wisconsin instructed in wood utilization; Mr. Earl J. Rogers of the Department of Forest Economics Research of the Forest Service in Washington instructed in forest mensuration; and Mr. A. Hyndman Stein, FAO forester with the Inter-American Institute of Agricultural Science at Turrial-

ba, Costa Rica lectured on forest policy and directed and summarized the round table discussions of individual country problems.

The objective of this course was to offer, in so far as possible, a balanced program aimed at satisfying the greatest needs of most of the participants. As the individual needs of each country and the basic technical training of each participant varied, it was impossible to give everybody exactly the emphasis most desired. However, in being general in its coverage, the course was directed toward the basic aims.

The scheme of presentation included an attempt to define and show forest problems, to clarify their magnitude and the priority of their solution, and to offer some suggestions for action. Three training techniques were used:

1. **Lectures** by technical personnel using slides, films, personal experiences, research findings and material from texts.
2. **Field trips** to problem areas so participants could see first-hand what could be done. Where practical, the students actually participated in the "doing".
3. **Round table discussions** using the participants own problems as the subject. This allowed each participant to see other's problem and to consider suggestions and experiences of the group relative to its solution.

Much of the presentation, for lack of tropical experience, had to be based upon findings in the temperate zone. Where this was necessary a special effort was made to interpret the material in a form applicable to the tropics, and to recognize the distinction between universally applicable principles and those details which must differ from place to place. The presentation was geared, in so far as was possible to the stage of advancement of the countries represented. The students themselves participated in discussions concerning their special experiences and conditions throughout the course. They were at all times kept aware of the magnitude of Puerto Rican forest problems and the need for parallel progress toward their solutions.

This year 21 trainees from 12 countries attended the course, as follows:

Gilberto Acosta Ayala - Puerto Rico
Ranger, Commonwealth Division of Forests

Diniz Xavier de Andrade - Brazil
Professor of Silviculture, Northeast College of Agriculture, Paraiba, Brazil

Jorge Enrique Becerra - Colombia
Forestry Superintendent, Servicio Técnico Agrícola Colombiano Americano

Domingo Bermúdez - Puerto Rico
Ranger, Commonwealth Division of Forestry

Moisés Augusto Berríos - Nicaragua
Forestry Technician, Ministry of Agriculture, Managua, Nicaragua

Eustace Araon Bradley - British Honduras
Forester, Government of B. H., Belize

Joseph Clairmonte Clarke - St. Lucia
Forest Guard, St. Lucia Goverment Forest Service

Jaime Galindo - Colombia
Assistant Forest Superintendent, Río Calí, Colombia

Wenceslao Tovar-Mozo - Colombia
Assistant Lawyer, Free Lands Section, Ministry of Agriculture

Norman B. Vickers - Jamaica
Divisional Forest Supervisor, Jamaican Forestry Department

Conrado Gómez - Colombia
Forest Superintendent, Manizales, Colombia

Jacob Guerrero - Perú
Superintendent of Iquitos Forest

Gregor Armstrong Hall, - St. Lucia
Ranger with Government of St. Lucia

John Kingsley Howes - Montserrat
Agricultural Assistant, Agri. Dept.

Eduardo Izquierdo - Perú
Superintendent of Pucalpa Forest

Fitzroy Johnson - Trinidad
Forester, Trinidad Forestry Department

Back Row - L. to R.: Meyer Solano, Costa Rica; Frank Wadsworth, U.S.F.S. Research Center Leader; Eduardo Izquierdo, Perú; Fitzroy Johnson, Trinidad; Diniz Andrade, Brazil; Steadman Ricketts, Jamaica; Norman Vickers, Jamaica; Domingo Bermúdez, Puerto Rico; Gregor Hall, St. Lucia; Victor López, Puerto Rico. 2nd Row - L. to R.: Ralph Throop, U.S.F.S. Puerto Rico Training Officer; Jacob Guerrero, Perú; Jorge Becerra, Colombia; Wenceslao Tovar, Colombia; Eustace Bradley, British Honduras; Moisés Berríos, Nicaragua; Jaime Galindo, Colombia; Cristóbal Flores, Puerto Rico. Front Row - L. to R.: Gilberto Acosta, Puerto Rico; Richard Kpan, Liberia; Conrado Gómez, Colombia; Victor Ortiz, Puerto Rico; Earl Rogers, U.S.F.S. Washington; Joseph Clarke, St. Lucia. (Missing from picture - John Howes, Montserrat).

Richard Kanwie Kpan - Liberia
Forest Supervisor, Dept. of Agriculture and Commerce, Monrovia
Víctor López Fumero - Puerto Rico
Ranger, Commonwealth Division of Forestry
Víctor R. Ortiz Vázquez - Puerto Rico
Ranger, Commonwealth Division of Forestry
Steadman E. Ricketts - Jamaica
Divisional Forest Supervisor, Jamaica Forestry Department
Meyer Solano, Conejo - Costa Rica
Chief of National Forest Department
Ministry of Agriculture and Industries, San José

SUBJECT MATTER AND GENERAL PROGRAM

From the following description of the subject matter, the reader can readily see the broad scope of the program. From questionnaires and appraisals made out by the students and instructors at the end of each annual course, suggestion have been received which result in changes in the program each year. The following was the program for 1958:

PHYSICAL ARRANGEMENTS AND ORIENTATION

The first week was spent in getting the students settled. The Office of Technical Cooperation welcomed them and pointed out through lectures and visits the points of interest and other information the students should know about the island and its government. Lectures were presented on the education, industry, agricuture, and the history of forest conservation in the island.

DENDROLOGY AND ECOLOGY — 4 DAYS

Here were explained the bases for classifying tropical trees and forest associations. The students collected leaf specimens and learned the technique of preparing simple field keys for their identification. The major tropical forest formations and associations were described.

ARTIFICIAL REGENERATION — 6 DAYS

Since such a large percentage of potential forest land has been depleted of trees and is in need of reforestation in so many countries, considerable times was spent on this course showing through all steps how it could be done. This covered seed collection, testing, sowing, nursery practice, field planting, and plantation care. Trips were made to a nursery and to several established plantations.

SILVICS AND SILVICULTURE — 6 DAYS

This subject dealt with the natural characteristics of tropical forests and methods of improvement, including density, composition, and quality. Practices included were thinnings, removal of inferior species or deformed trees, and selection of crop trees. Field work included inspection of unimproved and improved forests and actual work in both mixed stands and plantations.

FOREST MENSURATION — 10 DAYS

Included here were lectures and field practice in land surveys, volume and growth determinations of standing trees, volume of logs, volumes of manufactured products, the layout of a forest survey, and the use of aerial photographs in mapping, determining forest areas, types, and volumes.

FOREST MANAGEMENT — 2 DAYS

This subject covered the operation of the forest on a business basis, how the cut and yield can be controlled, how to determine land values, and finance. Included was a complete description of the Luquillo pilot-management program, involving compartmentation and use of area and volume control.

FOREST RESEARCH — 2 DAYS

Included here were the analyses of forest problems, the decisions as to relative priorities of different lines of investigation, objec-

tivity in comparative research, how to start on a modest basis, and the necessary steps inherent to all reliable experimentation.

FOREST UTILIZATION — 10 DAYS

The various properties of woods and their significance to utility were described. Through the use of films and samples a large number of forest products were shown as well as equipment for their manufacture or processing. Visits were made to the pilot preservative plant of the Center, the local paper mill, a furniture factory, and a new pressed board plant. A large number of pertinent Forest Products Laboratory pamphlets were issued to the students.

FOREST PROTECTION — 1 DAY

Discussion centered around the importance of recognizing the extent of damage and control measures for the three major injurious agencies: fire, insects, and disease.

PUBLIC FORESTRY — 3 DAYS

This covered the place of the government in the control and management of forested areas. The U. S. system of management was presented here as one example. The students were shown how the National Forests are organized and administered.

PRIVATE FORESTRY — 2 DAYS

The four local agencies concerned directly with the management of private forest lands: the Division of Forests, the Extension Service, the Soil Conservation Service, and the Agricultural Conservation & Stabilization Service presented a panel discussion on their respective roles in this field. Private forest plantings resulting from the Clarke-McNary and Cooperative Forest Management programs were visited.

SOIL CONSERVATION — 1 DAY

A day in the field with technicians of the Soil Conservation Service to see problems and results of field work.

ALLIED FOREST RESOURCES — 3 DAYS

Field trips were taken to observe what is being done in the way of utilizing forest lands for other than forest crops. Visited were a small, modern and efficient water treating plant, a fish hatchery, recreation areas, and soil protection areas.

FOREST LEGISLATION AND POLICY — 1 DAY

The vital importance of any country having prepared a sound policy regarding land use for forestry, water, agriculture, etc. was pointed out. Results of countries failure to do so were pointed out and highlighted. How policies can be developed were discussed.

FOREST PROBLEMS IN TRAINEES COUNTRIES — 4 DAYS

Participants from each country were given an opportunity to prepare a statement covering the more important phases of his country as regards to location, area, physical geography, and specific problems faced. This acted as a summary of the entire course as students were then able to see how the entire training program fit into the overall picture as dictated by the specific problems of each country.

In this entire three-month program the participants spent a total of 64 percent of their time in the classroom and the rest in the field. Of the 1,260 mandays spent there were no accidents but there were at least 30 mandays loss through illness, or absence for personal reasons. One student submitted to a major operation which caused him to miss two weeks of class.

The student who traveled the greatest distance to attend was the participant from Liberia, Africa.

The staff of the Tropical Forest Research Center is looking forward to next year's course. Each member feels that he has gained a great deal through knowing and working with the representatives of these neighboring countries and has experienced the feeling of doing something to improve the lot of his fellow man.

Observations on Some Caribbean Forests

By W. S. CHALMERS 1/
Department of Botany
University College of the West Indies
Jamaica

SUMMARY

The writer describes visits made to Haiti, the Dominican Republic, Puerto Rico, British Guiana, and Trinidad. Several aspects of the forestry programs in the different countries were studied with the principal interest being the natural forests of *Pinus occidentatis* Sw. of Hispaniola and the establishment of *Pinus caribaea* Mort. in Trinidad and British Guiana. The progressive forest policy adopted in Trinidad has resulted in an admirable forest estate.

ACKNOWLEDGMENTS

The Cross Trust (Perth. Scotland) furnished the grant without which the trip could not have been made. Their interest is sincerely appreciated. Thanks are due also to the foresters in the various places visited. Their hospitality and enthusiasm contributed much to make the trip both instructive and enjoyable.

INTRODUCTION

During January and February 1958 a tour of some of the forest areas in the West Indies was made to observe forestry practices and programs in those areas. The following account is based on observations and notes recorded daily. It is not intended to be highly technical nor critical but rather a presentation which may be of interest to foresters in the area, who cannot gain the experience by personal visits to their neighboring countries.

1/ Mr. Chalmers holds a Leverhulme overseas research scholarship at U.C., W.I.

HAITI

The first stop was in Haiti to visit the natural forests of *Pinus occidentalis* in the southeast portion of the country. Through the cooperation of the Societe Haitiano-Americaine de Development Agricole (SHADA) several days were spent in the Foret de Pins in the Mornes des Commissaires area. This area ranges from 3250 to 6800 feet in elevation and with a five to six-month dry season from December to April has an annual rainfall of 65 inches. Although the normal winter temperature is between two and five degrees, it may fall as low as two or three degrees below zero Centigrade.

Geologically the area is of Eocene limestone giving rise to a reddish brown clay loam soil of variable thickness. On steep slopes there is often only an inch of two of soil with frequent outcrops of sculptured limestone. On gentler slopes 12 to 18 inches of soil cover the red stained parent material which the pine roots apparently penetrate with ease. The surface litter, composed mainly of pine needles and twigs, may form a layer up to three inches deep.

THE TREE CROP

Pinus occidentalis is believed to exist naturally only in Hispaniola and eastern Cuba (1) 1/. It is a species closely allied to *P. caribaea* Mort. and is commonly known in Haiti as "bois pin". According to the Flora D'Haiti (2) its altitudinal range is above 2600 feet. The tree occurs in pure stands over many thousands of acres broken occasionally by farm lands or rain forest. With

1/ Numbers in parenthesis refer to references in literature cited.

the falling or burning of the rain forest, the pine rapidly encroaches to the exclusion of most other species except *Didymopanax tremlum* Kr and Urban. Mature specimens are invariably of excellent form with a DBH of 5 to 6 feet, a total height of 90 to 110 feet, and a clear bole of up to 50 feet. These mature trees posses typically flattened crowns.

A noticeable feature is the abundance of natural reproduction of all age classes throughout the crop even under quite dense pole-size stands. Unfortunately most of this regeneration is lost or becomes very spindly because of the intense competition since there is insufficient labor to undertake the necessary thinning or release. This is especially true in burned areas. Natural regeneration is not so prolific in wet depressions and valley bottoms nor are the mature trees of such large size as on the slopes and ridges.

Among the commonly occurring ground vegetation plants are the following: *Bocconia frutescen* Lx., *Agave* sp., *Ilex* sp., *Rubus* sp., *Lycopodium* sp., *Ipomoea* sp., *Vaccinium* sp., *Fragaria* sp., *Pterdium* sp., and *Didymopanax tremulum*. In addition there are a number of species of grasses. The *Agave* sp. are most frequent on the dry steeper slopes.

Seed Production

Local residents believe that at elevations above 5000 feet the trees do not bear seed until they are 30 to 40 years old. At lower elevations it seems likely that fruiting occurs at younger age though site quality may affect age of fruiting. (Four-year old *P. occidentalis* planted at an elevation of 1500 feet in Jamaica bore a few cones last year). Male and female flowers were abundant at the time but, according to the natives, seed years vary widely.

Seed is collected from December to March only from trees felled during the annual coupe. Special equipment would be necessary to collect seed from the best trees because of their great height. It is unfortunate that such equipment is not available because SHADA, which is responsible for the management of these forests, has rarely been able to meet the annual demand for seed.

HARMFUL AGENCIES

Fire is by far the most destructive agency. Mature trees appear able to survive the severest scorching because of their very thick bark. Young trees with thinner bark are less resistant and extensive areas in the younger age class have been destroyed by fire. Areas with young regeneration are highly susceptible to damage because ground fires spread rapidly and often spread into the crowns. December to April is the most hazardous period and in 1950-51 nearly 11,000 acres were affected by fire during this season. During 1957 there were 17 outbreaks in April and 9 in May. The principal causes are listed as farmers, travelers, and incendiarism by local people.

Grazing of cattle in the forest is common and the occurrence of isolated dead trees is invariably caused by the girdling of the tree by the tethering rope.

The forests have until recently been relatively free from insect and fungus epidemics. During 1957, however, widespread deaths occurred among younger trees due to a scale insect which was identified in the Dominican Republic as the cottony cushion scale, *Icerya purchasi* Maskell. This insect, a functional hermaphrodite, is no doubt partially controlled by a dipterous parasite *Cryptochaetum iceryae* Williston (3). White cottony egg cases were seen everywhere though once vacated they are easily washed or blown off. An attack is then evidenced by small yellow puncture holes. Needles brown and fall quickly, usually from the lower branches upward though in some instances the re-Reverse occurs. Trees attacked by the scale insect seemed to be very susceptible to a root fungi and rot quickly at the ground level.

Resinous gall-like structure were found occasionally in newly developing lateral and terminal buds and among the young clusters of leaf fascicles. These structures which may be of traumatic origin as a result of the egg laying of a spider, invariably lead to the atrophy of the stem where they occur.

TIMBER

In Haiti the wood of *P. occidentalis* is known as "bois chandelle". In the mountains it is used for fuel; throughout the country its use for construction purposes is increasing. An examination of several stumps showed the growth to be generally very uniform averaging 6 to 7 rings to the inch. Growth rings were clearly defined with false rings sometimes discernible. Wellwood (4) in a study of the wood properties concluded that in most respects it equalled the wood of the British Honduras pitch pine *P. caribaea*. Harrar and Reid (5) showed that the timber will retain amounts of creosote oil far in excess of the minimum specified by the American Wood Preserver's Association.

PLANTING P. OCCIDENTALIS IN THE TROPICAL COUNTRIES

In recent years seed has been sent by SHADA to many countries in search of a fast growing conifer having desirable wood properties. Recipients include Peru, Ecuador, Brazil, Australia, New Zealand and East Africa. Australia reported a high percentage of failures with seedlings planted on a number of coastal areas between 17 and 27 degrees latitude South. In Jamaica, however, small trial plots at elevations between 1000 and 2000 feet on a variety of soil have shown exceptionally good growth. In 1957 trees in one 4-year old plot overaged nearly 4 inches in d.b.h. and 20 feet in height; maximum sizes were 5.5 inches and 27 feet respectively.

From observation in its native range it appears that *P. occidentalis* should be a desirable species to test and would probably succeed best on site elevations above 2000 feet with moderate rainfall.

DOMINICAN REPUBLIC

A short time was spent visiting the *P. occidentalis* forests in the center of the country near Jarabacao and Constanza. Here, at an elevation of 4000 to 6000 feet, the pine grows on a clay loam soil derived from rocks of volcanic origin. The maximum temperature during June, July and August reaches 27 to 29 degrees C. while in December, January and February frosts are experienced.

Although not as large here as those seen in the Forest des Pins, the trees were of fine form. Natural regeneration was prolific and here too the pine forests were reported to be spreading following clearing of the Rain Forest.

The field layer in general was sparser than that encountered in Haiti. Some of the most common species present were *Bocconia frutescens*, sp., *Bidens pilosa*, *Vaccinium* sp., *Agave* sp., *Odontosoria fumarioides*, *Pteridium* sp., and *Blechnum* sp. In addition there were several species of grasses and one or two Melastomaceous shrubs. Russula sp. was a common ground fungus.

SEED BEARING

At that time, early January, dense clusters of dull red unopened male flowers were a common sight. In this region trees, certainly less than 20 years old, bore cones in varying quantities. The cones remain firmly attached to the branches after seed dispersal. This is rather deceptive since the cones tend to reclose after seed fall.

At Constanza an interesting experiment was in progress to determine the effect of removing the leading shoot at 3 or 4 years on flowering and fruiting. Five-year old trees about 15 tall had extremely heavy side branches, were laden with male and female

flowers, and bore a few mall cones. This heavy induced flowering was the first step in an effort to obtain a quicker, more accessible source of seed.

HARMFUL AGENCIES

Less evidence of fire damage was seen in the Dominican Republic. Neither was there much evidence of injury by the cottony cushion scale. Instructions have been issued that forest guards report the first sign of infection so that immediate control measures might be instituted. The resinous gall-like structures were just as common as they were in Haiti.

TIMBER

Emphasis has been placed on utilization and two modern sawmills were visited, one at Tireo the other at Constanza. The 3-year old mill at Tireo is the second largest in the country. Diesel powered, the mill has a capacity of 100,000 cubic feet per month but was producing only 40 to 50,000 feet; 90 to 100 men are employed. The mill handles only pine logged in the surrounding districts. Much of it is sawn to specified sizes for use in the Government home construction programs. Both of the sawmills visited were equipped with large, modern, dry kilns.

Most of the sawn timber showed very uniform growth rings varying from 6 to 8 per inch. The product from one particular coupe being felled was extremely knotty. Another defect noticed in some boards was the occasional presence of resin plates best described as resembling tight translucent knots.

VARIATION IN P. OCCIDENTALIS

In both Haiti and the Dominican Republic there was a noticeable variation in bark characteristics and needle form. The former may be simply a matter of age. The length, texture, and number of needles per fascicle varied. Needles were usually 8 to 9 inches long and fairly coarse but a more delicate, finer type 5 to 7 inches long was seen occasionally. In both countries random counts were made of the number of needles per fascicle; they varied from 2 to 5 per fascicle with 3 the most common, though fascicles with 4 needles were surprisingly common. A similar condition occurs in *P. caribaea* Mort which is described as having 2, 3 or more needles (1).

THE FOREST ESTATE

The Dominican Republic is fortunate to have over 65 percent of its land still under forest cover. These forest resources are gradually being developed to a greater degree than heretofore, especially with the provision of an extensive system of forest roads.

The minimum size of tree than can be felled is specified by law. In addition any area that has been clear-felled may remain under cultivation for two years and must then be reforested or put under permanent pasture in an attempt to prevent erosion.

PUERTO RICO

Two weeks were spent in Puerto Rico with personnel of the Tropical Forest Research Center of the U. S. Forest Service. The first week was devoted primarily to reference work in their excellent library.

In the field two current projects were of special interest since they may in the future have an effect on forestry in other Caribbean countries.

UTILIZATION OF CECROPIA PELTATA L.

Prior to a year ago this species, known locally as yagrumo hembra, was just another weed tree; more prolific and faster growing, perhaps, than most other species in that class. However, in terms of volume, it is near the top of the list of Puerto Rico's for est trees. It was decided that any forest utilization program should consider the use

Fig. 1 - Yagrumo logs piled at "Insuldyne" plant awaiting processing into excelsior. Ponce, Puerto Rico. 1958.

Figure 2. - Forest officers inspecting the cement-excelsior product "Insuldyne produced at the Ponce plant. 1958.

of this tree a worthy project. A study of its properties and actual tests showed that it could be shreded easily and used as a substitute for the excelsior previously made from temperate pine species, mixed with cement in the manufacture of a building board known as Insuldyne. A modern factory has been erected near Ponce on Puerto Rico's south coast which will require 10,000 cords of wood annually. Fig. 1 and 2.

Trees 5 inches d.b.h. and larger can be utilized. On the Luquillo Experimental Forest trees to be harvested are selected and marked by forest rangers and sold on the stump to the highest bidder. All woods operations are performed by the purchaser or by labor hired or under contract to him. Felled trees are bucked into 5 foot bolts and extracted to the roadside by oxen, hand, or by gravity on wire cable and then beaten with a club to remove the bark. The peeled bolts are then stacked and measured in cords and later transported to Ponce by truck. Larger trees are converted into logs and sold by the thousand board feet. Investigations are being made in an attempt to improve logging operations by mechanization where possible as extraction on the steep slopes and mountainous terrain is troublesome and expensive. Accessibility at present limits the sale areas to those near roads. (Fig. 3)

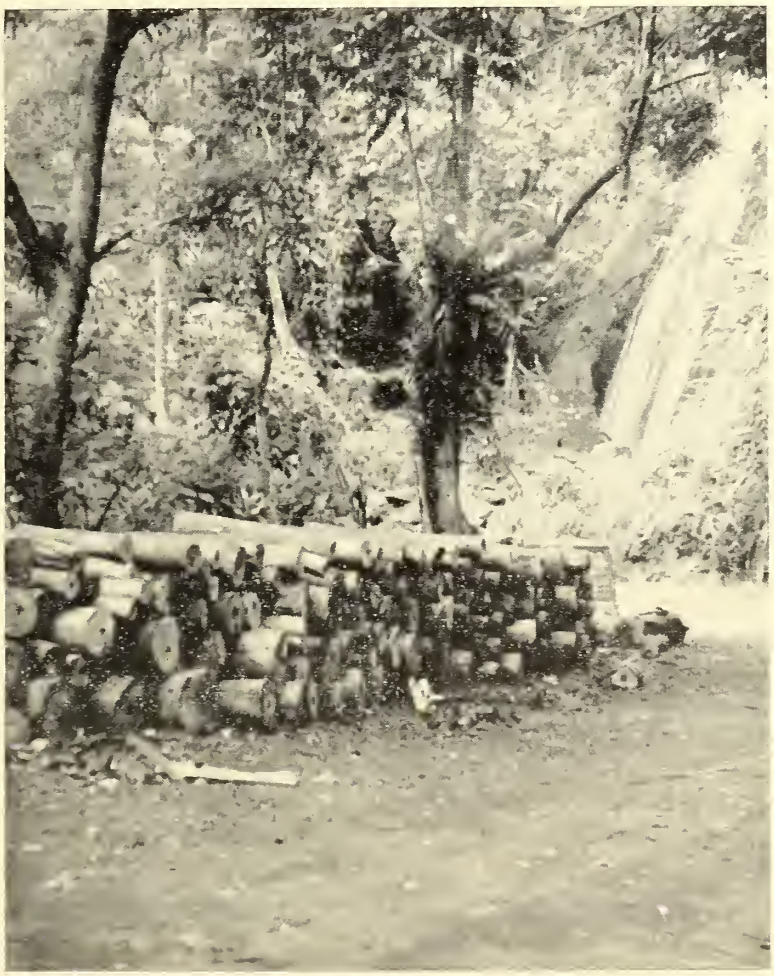

Fig. 3. - Yagrumo bolts stacked along road waiting transportation to mill. Luquillo Forest. 1958.

On one area visited in the Tabonuco type in the Luquillo Experimental Forest had Cecropia trees up to 24 inches d.b.h., much larger than any seen in the other countries visited.

Preliminary investigations into the natural and artificial regenerations of Cecropia have been instituted to determine how to increase the supply in existing forests and for reforestation of steep lands which should be under forest cover. Inquiries are also being made into the possibility of importing this timber from other countries.

TIMBER STAND IMPROVEMENT

Very little virgin forest remains in Puerto Rico and the secondary forest stands include many trees regarded at present as undesirable due to species or poor form. Much can be done in such heterogeneous degraded tropical rain forests to improve the composition by the removal of some of the undesirables to favor the better trees. In Puerto Rico this subject of timber stand improvement has been given considerable attention particularly as to the best methods of effecting the improvement operation.

For a number of reasons normal felling is not always considered the best method to employ from either the silvicultural or economic view-point. In recent years a great deal of research has been done particularly under temperate conditions on the use of poisons and chemical growth regulating compounds to kill unwanted trees. One such experiment was initiated in January 1958 by the Tropical Forest Research Center designed "primarily to test certain methods using chemicals, concentrations and techniques which have given fairly consistent kills in other places or modification of such methods which if successful would simplify their tropical application" (6).

In this study seven treatments were tested on a number of species. Treatments included a simple double-hack or chip girdle and six chemical treatments using ammonium sulfamate (Ammate) and 2,4,5-Trichlorophenoxyacetic acid (2,4,5-T). In the chip a continuous ring of wood 2 to 3 inches wide and one-half inch deep is removed. The 6 poisoning treatments were as follows:

1. Single frill girdle with 19.3 percent solution of Ammate.
2. Single frill girdle with a 2 percent mixture of 2,4,5-T and water.
3. Basal incisions with a 10 percent mixture of 2,4, 5-T and water.
4. Basal bark spray with a 5 percent mixture of 2,4,5-T and oil.
5. Incised bark spray with a 20 percent mixture of 2,4,5-T and water.
6. Normal bark spray with a 20 percent mixture of 2,4,5-T and water.

The treatments were replicated and applied in late January during the dry season when trees were least active. Records were kept as to the amount of time and chemical required for each treatment.

Treated trees will be examined after 2, 6, 12, 24, and 36 months to determine amount and rate of crown kill, sprouting, and the rate and method of deterioration and fall of killed trees. Results which the Research Center intends to publish in the second or third year will no doubt prove valuable to others concerned with the improvement of degraded secondary forest in tropical regions.

Two other items in Puerto Rico were of special interest. The first is the Research Center's work with pine. No species of Pinus had ever been successfully established on the Island despite several tests with a variety of species over a number of years. There is now, however, in the Maricao forest a small but interesting plot of *Pinus elliottii* Engel., that has reached a stage of development never before attained. These seedlings along with a number of several other species were planted in 1954 and the next year exhibited the usual unthrifty appearance. In July 1955 the soil around some of the *P. elliottii* seedlings was innoculated with mycorrhiza-bearing humus and A-1 horizon soil material

obtained under plantations of *P. echinata* and *P. taeda* in the southeastern United States. A number of trees were left untreated as controls. The plot has been examined and the trees measured regularly. When examined in January 1958. though the best trees could not all be described as vigorous, they were in every case trees whose roots had been innoculated with the mycorrhiza-bearing material. All the check seedlings were very unhealthy; some had died. (Fig. 4). This experience emphasizes the need for research into the role of mycorrhiza in the establishment of pine species on the Island.

Fig. 4. - Effect of mycorrhizae applied to soil around pine seedlings (Pinus ellioti). **Seedling at left 5 years old (untreated). Seedling at right same age (treated).**

The final item concerns an aspect of forestry not often in evidence in the West Indies, namely Amenity. The accessibility and excellent facilities—restaurant, swimming pool, picnic shelters, cabins, etc. available for use by the public at the La Mina Forest Recreational Area in the Luquillo mountains, could well be emulated in other countries. Certainly in Puerto Rico the annual total of visitors to La Mina proves the popularity and good use made of such facilities, which at the same time must surely make people more forestry conscious.

BRITISH GUIANA

Fourteen days was too short a period to ever attempt to get an overall picture of forestry in this vast country where 80 percent of the land is forested. Most of the

available time was spent in the Greenhart *(Ocotea rodiaei* Mez.) forests in the Bartica Triangle and visiting the recently established Forest Department plantations of *Pinus caribaea* near Bartica.

DEMERARA GREENHART

Fanshawe (1) describes the greenhart as an evergreen canopy tree (attaining heights of up to 130 feet and diameter of 40 inches) occurring as a dominant and moderately gregarious species over small areas of rain and evergreen seasonal forests on light sandy loam soils, being occasional to locally frequent in other types of forest on any kind of soil. The species prefers a mesophytic habitat though it grows under conditions of physiological drought as in the Mora *(Mora excelsa* Benth) and Wallaba *(Eperua falcata* Aubl.) forest.

Through the kindness of British Guiana Timbers, Ldt. it was possible to visit their current logging site near Ikuribisi. Briefly their harvesting procedure is as follows: The virgin forest is surveyed and demarcated into compartments. A 25 percent strip cruise is made to estimate the merchantable volume of greenhart in each compartment and to determine the most suitable locations for roads and storage points (termed markets). After felling the giant trees are hauled by huge tractors to a market where they are measured and booked. Eventually they are transported by powerful lorries to Winiperu on the River Essequibo to begin the final stage of the journey by barge to the Houston mill on the River Demerara. At this sawmill, said to be the largest in South America, the logs are converted to sawn lumber often directly to specifications for particular projects. Besides being sawn into lumber, greenhart is supplied in the round for use as piling and also as hand hewn squares.

PINUS CARIBAEA

The first trial plot of *P. caribaea* in British Guiana, planted in 1954, used transplants raised from seedlings flown in from Trinidad. The planting site was cleared of the secondary bush and the six months old transplants planted at a 6 by 8 foot spacing (7 by 7 feet is now standard practice) and dressed with two ounces of superphosphate. The trees were pruned when 3 years old and in February 1958 varied from 15 to 20 feet in height and from 3.5 to 5 inches d.b.h. The trees were not of good form; double leaders were fairly common and a number of trees showed a pronounced curvature near the base. There appeared to be no correlation between the age of the tree and the number of branch whorls. Nearby on the former transplant beds a number of plants had been left under fairly heavy shade. Though the same age as those on the nearby plot, the trees under shade were not more than 12 to 15 feet tall but were of better form and more uniform in appearance.

Some recently established plots near the five mile post on the Bartica-Potaro road were visited to observe the more or less perfected technique used to establish *P. caribaea* on the infertile white sandy soils of worked-out Wallaba forest. The secondary forest is cleared and burnt over prior to planting with locally raised transplants grown from British Honduras seed. Mycorrhiza is believed to be a factor in successful growth and the transplant beds are supplied with mycorrhiza infested mother trees at six-foot intervals; the infection is from the original Trinidad stock. The transplants are six months old and eight to twelve inches tall when planted barerooted. Each tree is dressed with two ounces of superphosphate.

A dense ground vegetation, bracken spp. being most prominent, appears quickly after burning. Initially this vegetation provides shade beneficial to the young plants; however, its growth is so rapid that cleaning cannot be long delayed.

In February 1958 trees planted 2 months earlier were 18 to 30 inches tall while some planted in July 1956 were 4 to 5 feet tall. The only harmful agent noted was the cutting

ant (*Atta* spp.) which defoliates and often kills the young pines.

TRINIDAD

One week was spent in Trinidad studying three forestry projects on that island: The establishment of *Pinus caribaea* plantations; the growing of teak (*Tectona grandis* Linn F) in plantations; and the tropical shelterwood system of silviculture as locally applied.

PINUS CARIBAEA

The first attempt to establish this pine almost a decade ago met with little success. However, the results obtained since 1952 seem to indicate that for sandy soil of low fertility the technique has been mastered.

Nursery practice — Pine nurseries at Comuto and Brickfield were visited. These nurseries use methods evolved in British Honduras. Concrete germination beds are located under permanent shelters with alternate translucent roofing panels. The beds are filled with pure washed sand; the seed is sown broadcast or in rows one inch apart and covered with a thin layer of washed fine gravel Damping-off is virtually non-existent and the seedlings looked extremely healthy. The seeds are sown in November or December and transplanted about four weeks later. Seedlings normally develop very long tap roots, usually without laterals, which may require pruning before transplanting at a 3 by 3-inch spacing in specially prepared beds. The nursery worker's task has been made less arduous by raising the germination beds to waist height.

The transplant beds are made up of soil, sand, and pen manure mixture to give a consistency that enables the material to be cut with a machete into 3 x 3 x 3-inch blocks, each block holding a single transplant. Transplant beds are kept thoroughly weeded and a pine needle mulch is applied. Shade is provided either by a temporary shelter of palm leaves or by a more durable split bamboo cover which can be rolled up. Seedlings in the transplant beds are usually root pruned at least twice between March and May (8). The planting stock produced is usually in the form of six month old transplants 8 to 10 inches tall.

Site preparation-taungya — The recent pine coupes in the Longstretch Reserve were established in much the same way as were the extensive teak plantations on the island. The larger trees in an area of poor secondary forest are bought and felled by timber merchants and charcoal burners are allowed to work over the area in the year preceding the entry of the gardeners. The coupe is burnt over in late April before the gardeners enter. This probably destroys much of the humus but the increased potash resulting from the burn undoubtedly helps both the trees and the catch-crops. The tree crop is planted in June of the following year, during the rainy season, at a spacing of either 7 x 7 feet or 8 x 7 feet. Before the trees are felled each gardener is allocated an area to cultivate, rarely more than two acres, for which he pays a nominal rent. The gardener is responsible for felling all trees not cut for timber or charcoal; frequently the gardener is also the timber licensee or charcoal burner. He is limited to the use of certain annuals but he may plant cassava and pigeon peas. Corn, dasheens, and hill rice are other common crops. It appears that some crops are more effective than others in keeping down the various grasses which compete seriously with the tree crop in their early stage of development. For the first three years after the gardeners leave an area, weeding is usually done to free the trees from competing grasses.

A small plot was noticed in the 1956 coupe where the gardener had been allowed to grow crops for two years instead of the usual one. Trees on this area showed a distinct increase in height growth over the remainder of the coupe.

Nine months after planting a number of light demanding tree species were in evidence in the 1957 coupe in addition to the fairly abundant fern, sedge and grass species. The most prominent were melastomaceous species except for Cecropia peltata L. Natural regeneration of *C. peltata* has been prolific in both the 1956 and 1957 coupes obviously thriving on the fresh mineral soil after clearing and burning. This species alone, because it is so prolific and fast growing, will likely increase weeding costs a great deal on such sandy sites before the pine canopy closes.

The cutting ant (*Atta.* spp.) systematically defoliates the young pines and frequently cause some mortality. The ant nest are treated with a solution of Aldrex but it is difficult to eradicate them entirely

Rate of growth — In the Longstretch Reserve height increment in the first year reaches up to three feet. Where cultivation had been carried on for two years in the 1956 coupe, some of the trees were 15 to 20 feet tall. Height growth in the 1952 Piarco Road plot was most impressive. The tallest trees in this plot were up to 35 feet in height and were 6 to 7 inches in diameter; trees averaged 25 feet tall with d.b.h. of 4 to 5 inches. An adjoining plot one year younger was almost identical.

There was a great variety in tree form in all the plots visited. Form varied from the tall spindly type frequently devoid of branches to the very branchy form usually without a definite leading shoot, or with several vertically growing branch shoots competing with the leader. Strange to say, the best formed pines seen were in the 1950 plot in Arena forest where the trees had been suppressed by hardwoods for two years. Three distinct forms are recognizable by their different habits and leaf characters in one-year old plants and were pointed out in the Brickfield area by the local forester.

The irregular whorl forms mentioned were also seen in *P. caribaea* plots in British Guiana and in Jamaica in the closely related *P. occidentalis* and in *P. patula* Schl., & Cham. The same condition is described in *P. radiata* D. Don., planted in Australia in a paper by Jacobs (8). He suggests that the resting of the terminal bud while the subterminal branch buds are active is due to the condition of the buds during the 'adolescent state' of the tree. He found that while favorable conditions for growth continue, successive internodes are produced on the main stem and the main axis of the tree is able to keep ahead of the developing branch whorls. Unfavorable conditions, especially drought, force the growing tip to form a resting bud and it is this that causes most of the unfortunate whorl types and double leaders.

Seed bearing — A little variable seed which gave satisfactory seedlings was extracted from cones collected from four-year old trees in the Piarco plots. The flowering season appears to be during December and January.

TEAK GROWING

The first experimental plantings of teak in Trinidad date from 1913. A definite teak planting programme was drawn up in 1928 and since that time the area planted annually has gradually increased until in 1956 it reached 775 acres. At that time the Forest Department could boast a teak estate of 10,121 acres (11).

Some of the best teak in Trinidad has been grown on areas of calcareous clay interspersed with sandy loam which cover the low ridges in the south and center of the island. Detailed accounts concerning the establishment of those stands can be found in 1941 and 1943 issues of "The Caribbean Forester" and also in other publications by Lamb (8) (10). The present standard technique uses stump plants produced in nurseries located in or near the coupe to be planted. Two such nursery sites were visited. One site being used for the second time produced planting stock much inferior to the other; seedlings were up to three feet

shorter. For this reason the practice of using a nursery site more than once is usually avoided.

Site preparation and establishment is accomplished by the taungya system much as described under establishment of *Pinus caribaea*. A recent development has been the planting of pine in the teak coupe along the ridge tops where the growth of teak has always been found to be poorest.

The best stand of teak seen was the 1940 coupe at Brickfield. Initially planted at a 6 x 6 foot spacing there are now, after three thinnings, about 150 trees per acre with an average height of 50 to 55 feet and an average d.b.h. of 11 to 12 inches.

The 1955 coupe at Brickfield had suffered widespread damage from the cutting ant which in teak seems to be more selective usually attacking the newly developed leaves at the top of the tree. Fortunately teak seems to be more resistant to depredation than pine and can withstand severe attacks.

Brickfield Forest Industries — This is a compact little factory operated by the Forest Department which is kept fully occupied using all the products of thinnings, except possibly some of the first, from teak plantations for one purpose or another.

Trees to be removed in thinnings are marked by the Forest Department personnel and felled by contrators who buck the material into specified lengths. The contractor splits the material from the smallest trees into pickets on the site for use in making picket fencing at the factory. The fencing is made in 25-foot lengths in three sizes, namely 2, 4-1/2 and 6 feet high. When completed the fencing is rolled up and treated with a half and half creosote-dieseline mixture using the hot and cold bath process.

Larger trees removed in thinnings are sawn using a Gorwood circular gang saw to obtain scantlings in such a way that the thick slab material can be put through a roller feed resaw to produce floor boards. All saleable material is graded to standarize the product and help build up a large and satisfied market.

TROPICAL SHELTERWOOD SYSTEM

A number of coupes in the Arena Reserve were visited to observe the management of natural stands under the local technique of the tropical shelterwood system. The local technique was developed in the Arena area and the results are perhaps the most impressive aspect of forestry seen in Trinidad. The local application of the shelterwood system was based to a large extent on the activities of the charcoal burners at a time when there was a great demand for that product. Today this demand is rapidly diminishing and the effect that this and the generally expanding economy will have on the system has been summed up in a paper by Moore (12). The same paper also describes the application of the tropical shelterwood system in Trinidad.

Initially timber fellings and fellings by the charcoal burners were regulated so as to leave an exploited compartment with a shelterwood of dominant trees of marketable species. Intensive tending was carried out up to and including the seventh year with the shelterwood being progressively removed, when necessary, by poisoning. These intensive cleanings resulted in high establishment costs and since 1948 the amount of cleaning has been considerably reduced. Another factor which has tended to reduce the amount of cleaning is that some species formerly regarded as weeds now command a ready market. The carefully tended stands show the benefits of such intensive management. The 1940 and 1943 coupes are so uniformly well stocked with trees of excellent form that at first glance they look almost like planted stands.

Among the species most successfully regenerated in this way are *Tabebuia serratifolia* (Vahl) Nichols, *Didymopanax morototoni* (Aubl) Dcne & Planch, *Carapa guianensis*

Aubl., *Ocotea* spp., *Byrsonima spicata* (Cor) Rich., *Sterculia caribaea* R. Br., and *Terminalia obovata* (R&P) Stend. It is interesting to note that the studies have shown that there is no apparent relationship between the species in the shelterwood and the species regenerated (11). The inference is that regeneration is from seed already in the ground or that it is brought in by birds and bats which use the shelterwood as a perch.

The practice of supplementing natural regeneration by planting has been discontinued since generally enough natural regeneration is obtained. In some areas certain desirable species not present on the site have been planted as a future source. One such species *Simarouba amara* Aubl., a fast growing species indigenous to Tobago and Grenada, was planted under a shelterwood in the Arena Reserve in 1944. The shelterwood was removed by 1948 and in 1958 the planted trees reached a height of 60 feet and a d.b.h. of 12 to 15 inches.

By the end of 1956 Trinidad had almost 20,000 acres of natural and planted regeneration; this represents 1.7 percent of the total area. An excellent forest road system adds considerably to the forest estate. The concrete achievement in Trinidad should serve as an incentive to other countries in the West Indies. Their task has, however, been made somewhat easier than that in some countries by the preservation of large areas of natural forest and by the much lower elevations and gentler topography available for forestry.

LITERATURE

1. Dallimore and Jackson.
   1948. A Handbook of Coniferae.
2. Barber, H. D. and Dardean.
   1930. Flora D'Haiti.
3. Essig, E. O.
   1951. College Entomology. MacMillan.
4. Wellwood, R. W.
   The Physical and Mechanical Properties of pinus occidentalis. Caribbean Forester, Vol. 7, p 207.
5. Harrar and Reid
   1942. Retention of creosote oil in wood of pinus occidentalis. Tropical Woods, No. 71.
6. Huckenpshler, B. J.
   1957. Preliminary test of methods to kill undesirable tropical trees. Unpub. Study Plan.
7. Fanshawe, D. B.
   1947. Studies of the trees of British Guiana. 11. Greenhart. Tropical woods, No. 92.
8. Lamb, A.F.A.
   1956. Exotic forest trees in Trinidad Tobago. Government Printing Office.
9. Jacobs, M. R.
   Detection of annual stages of growth in the crown of pinus radiata. Commonwealth Forestry Bureau, Bull. No. 19.
10. Lamb, A.F.A.
    1956. Teak. Unpub. Forest Department. Paper.
11. Forest Department Trinidad & Tobago.
    1956. Annual Report.
12. Moore, D.
    1957. The effects of an expanding economy on the tropical shelterwood system in Trinidad. Government Printing Office.


UNITED STATES
ATLANTIC
OCEAN
GULF OF
MEXICO
BAHAMA
ISLANDS
MEXICO
CUBA
PUERTO
RICO
GUADELOUPE
DOMINICA
MARTINIQUE
STA. LUCIA
JAMAICA
HAITI
DOMINICAN
REPUBLIC
BRITISH
HONDURAS
CARIBBEAN SEA
HONDURAS
GUATEMALA
SALVADOR
NICARAGUA
TRINIDAD
PACIFIC
OCEAN
COSTA
RICA
PANAMA
VENEZUELA
BR.
GUIANA
COLOMBIA

The Caribbean Forester

U. S. DEPARTMENT OF AGRICULTURE
FOREST SERVICE
TROPICAL FOREST RESEARCH CENTER
RIO PIEDRAS, PUERTO RICO

VOLUME 19 NOS. 3 AND 4 JULY - DECEMBER, 1958

Caribbean Forester

El "Caribbean Forester", revista que el Servicio Forestal del Departamento de Agricultura de los Estados Unidos comenzó a publicar en julio de 1938 se distribuye semestralmente sin costo alguno y está dedicada a encauzar la mejor ordenación de los recursos forestales de la región del Caribe. Su propósito es estrechar las relaciones que existen entre los científicos interesados en la Ciencia Forestal y ciencias afines encarándoles con los problemas confrontados, las políticas forestales vigentes y el trabajo que se viene haciendo para lograr ese objetivo técnico

Se solicita aportaciones de no más de 20 páginas mecanografiadas. Deben ser sometidas en el lenguaje vernáculo del autor, con el título o posición que este ocupa. Es imprescindible incluir un resumen conciso del estudio efectuado. Los artículos deben ser dirigidos al Líder, Centro de Investigaciones Forestales Tropicales, Río Piedras, Puerto Rico.

Las opiniones expresadas por los autores de los artículos que aparecen en esta revista no coinciden necesariamente con las del Servicio Forestal. Se permite la reproducción de los artículos siempre que se indique su procedencia.

●

The "Caribbean Forester", published since July 1938 by the Forest Service, U. S. Department of Agriculture, is a free semiannual journal devoted to the encouragement of improved management of the forest resources of the Caribbean region by keeping students of forestry and allied sciences in touch with the specific problems faced, the policies in effect, and the work being done toward this end throughout the region.

Contributions of not more than 20 typewritten pages in length are solicited. They should be submitted in the author's native tongue, and should include the author's title or position and a short summary. Papers should be sent to the Leader, Tropical Forest Research Center, Río Piedras, Puerto Rico.

Opinions expressed in this journal are not necessarily those of the Forest Service. Any article published may be reproduced provided that reference is made to the original source.

●

Le "Caribbean Forester", qui a été publié depuis Juliet 1938 par le Service Forestier du Département de l'Agriculture des Etats-Unis, est une revue semestriele gratuite, dediée a encourager l'aménagement rationnel des forêts de la region caraibe. Son but est d'entretenir des relations scientifiques entre ceux qui s'interéssent aux Sciences Forestières, ses problemès et ses méthodes les plus récentes, ainsi qu'aux travaux effectués pour réaliser cet objectif d'amelioration technique.

On accept voluntiers des contribution ne dépassant pas 20 pages dactilographiées. Elles doivent ètre écrites dans la langue maternelle de l'auteur qui voudra bien préciser son titre ou sa position professionnelle et en les accompagnant d'un résumé de l'étude. Les articles doivent ètre addressés au Leader, Tropical Forest Research Center, Río Piedras, Puerto Rico.

La revue laisse aux auteurs la responsibilité de leurs articles. La reproduction est permise si l'on présice l'origine.

*The printing of this publication has been approved by the Director of the Bureau of the Budget (June 26, 1958)

Vol. 19 Nos. 3 and 4 July - December 1958

The Caribbean Forester

Contents

Sumario

Possibilities of Mexican and Central American Pines in the World Reforestation Projects

By: N. T. MIROV
California Forest and Range Experiment Station 1/
U. S. Forest Service, Berkeley, California, U. S. A.

and

EGON LARSEN
Forest Research Institute
Rotorua, New Zealand

Pines grow naturally only in the Northern Hemisphere, 2/ but they are also planted rather extensively south of the Equator. The largest pine plantations are located in New Zealand, Australia, Chile, and Union of South Africa. Smaller pine plantations may be found in any South American country. In the future there will be more planting of pines in both hemispheres. At present, *Pinus radiata* of California is the most popular pine in reforestation of the countries located in Southern Hemisphere. Mexican pines (such as *P. patula)* are used to a lesser extent, and in Europe they are planted chiefly in botanical gardens. The purpose of this paper is to call attention of world foresters to the possibilities offered by the Mexican and Central American pines for afforestation purposes.

Moreover, as tree-breeding is progressing rapidly in many countries, breeders should be interested in many good qualities of Mexican and Central American pines. In fact, at the Institute of Forest Genetics, of the U. S. Forest Service, near Placeville, California, Mexican *Pinus montezuma* was successfully crossed with local California *P. ponderosa.*

Mexico and Central America posses more species of pine than any other region of comparable size. The Central American countries are included in this paper because their pine forests are actually (except *Pinus caribaea* of the coast) a continuation of the pine forest of Mexico. Professor Dr. Maximino Martínez, of the Mexican Instituto de Biología, lists in his monumental work "Los Pinos Mexicanos" (Second Edition, Ediciones Botas, 361 pages, III. 1948) 66 different pines: 39 species and 27 varieties and forms. Dr. Martínez has been very conservative in describing new species; probably in the future more new pines will be discovered in Mexico and in the three Central American republics of Guatemala, Honduras, and Nicaragua.

Mexico and Central America offer pines that would suit many diversified reforestation projects. There are high elevation species, such as *Pinus rudis* or *P. hartwegii* that would thrive in temperate climates. There are pines of the warmer localities, such as *Pinus pseudostrobus,* or *P. herrerai;* these species grow surprisingly fast. There are real drought-enduring species, such as the piñon pines of northern Mexico. Some of the Mexican and Central American pines have possibilities as ornamental trees. Of outstanding beauty are: *Pinus lumholtzii* (Pino triste) with its drooping foliage, resembling a horses's mane, *P. pseudostrobus,* which is much planted in residential sections of Guatemala City, and *P. pinceana* of dry gulches in the state of Coahuila. *P. pinceana* from a distance looks more like a peppertree *(Schinus molle)* than

1/ Maintained at Bekerley, California, by the Forest Service, U. S. Department of Agriculture, in cooperation with the University of California.

2/ Reports that pines occur in Sumatra, south of the Equador are questionable.

a pine. *Pinus caribaea* of British Honduras (Belize) and of the Mosquito Coast of Nicaragua is an ideal tree to plant in many tropical coastal areas and islands. *P. patula* has become very popular as an ornamental in California.

The value of Mexican pines is generally accepted and many countries are keenly interested in obtaining seeds of the more important ones.

In the past, when a country wanted to plant authentic seed of a Mexican pine, the procedure was to send a trained forester to Mexico to explore and identify the species and to arrange for seed collection. Such were Loock's visit to Mexico in 1947 [3/] and sporadic collections of some American visitors. It appears that it is now time to organize seed collecting in Mexico by more satisfactory methods.

There can be no doubt that a large scale seed-collection mission to Mexico is needed. Many countries want seed of Mexican and Central American pines (and Mexican Douglas-fir), but the multitude of species and strains within each species and the lack of commercial tree seed merchants in Mexico have so far made delivery impossible.

Much time and money will be saved and much disappointment avoided if the large-scale use of Mexican and Central American tree species in world forestry can start on a sound basis. A world-wide comparative trial of species and strains is the obvious approach, but to establish such an experiment with what seed may be procurable from government or commercial sources in Mexico and Central America is at present quite impossible. It would not have the degree of uniformity that is desirable, and it would represent only part of this large section of the world.

3/ Loock, E.E.M. The pines of Mexico and British Honduras. Union of South Africa, Dept. of Forestry, Bul. 35, 1950. Early collection are fully discussed in this book.

Where to Collect

Mexico and Central America may be divided into at least 8 seed-collecting centers (see Fig. 1 and Table 1). These centers are of course, the centers of the most prominent forest regions. Table I shows the most convenient heaqduarters for each seed collecting center. Most of these places contain offices of local lumberman associations or some competent foresters. The table also shows the most important pines of the regions. For further information, the reader is urged to consult Dr. Martínez' "Los Pinos Mexicanos."

Ecological Difficulties

The many species and the existence of different ecotypes and varieties within each species makes it very difficult to determine what species or strain to collect and where to get it. Even if the forester could decide which species and strain would be the most suitable for his requirements, he would probably find it impossible to obtain the seed.

This situation is in many respects comparable to the one which existed after the first successful introduction of such American species as *Pseudotsuga menziesii*, *Pinus contorta* and *P. ponderosa* into Europe and elsewhere. Already at that early stage it was realized that the seed source (provenance) was very important, or in other words, that to a forester the species name was of limited significance without the tag of origin. A tremendous amount of research work has been carried out in many countries since then to determine which species and provenances were the most suitable for any particular locality. Considering the time and the effort spent on this work one might think that the forester by now would have the solution to these problems. On the contrary one finds a great deal of confusion and disagreement on the provenance problem.

In selecting the most suitable provenance for a given planting site, it is reasonable to look for a region within the natural range of a species that most closely resembles the planting site. Usually only a few factors such as temperature and precipitation are considered, and it is not fully realized that environments cannot be characterized by a few simple standard tests. In fact, it seems very doubtful if the growing conditions of any one locality are to be found in any other part of the world. As a strain or ecotype naturally is a product of the influence of all environment factors, it is not surprising that the result of such a selection usually is desappointing. Without present knowledge of the interrelation between plant communities and their environment it is obviously impossible to determine theoretically the most suitable seed source for a given planting site.

The only safe way — and undoubtedly the cheapest way in the long run — is to obtain seed samples at regular intervals throughout the natural range of each species and test their growth in the regions where the species are likely to be of importance. The distance between seed collection areas will naturally depend on the topography and climatic conditions in the region. There must be a certain amount of uniformity in an area before one seed lot can be said to be representative of the forest there. On the other hand, it would hardly be worth the effort to go into too great detail. If a "near-best" provenance (ecotype) can be found, further improvements can be achieved through selective breeding of this material at a far lower cost.

The junior author had the opportunity to deal with these problems during a seed cellection tour to the western United States in 1956. The object of the visit was to collect seed samples of the important forest trees of this region for species and provenance trials in New Zealand. Past experience had shown that interior species and provenances were not suitable for New Zealand conditions, so the seed collection work was confined to the region west of the Sierra Nevada-Cascade Mountains divide. The most important species *(Pseudotsuga menziestii, Pinus ponderosa,* and *P. contorta)* were sampled at intervals of approximately one degree latitude, and for each parallel at regular intervals of altitude, as well as from different aspects. A total of 160 seed samples were obtained during the 6 weeks the collection season lasted (each sample from 5 to 10 trees). Three forestry students from the University of California assisted in the cone picking. All the cones were shipped to a central place for extraction and cleaning of the seed. The work required some 15,000 miles of traveling by car, and the seed cost was about three times the total value of the seeds at catalogue price.

These details are given in order to convey some idea of what can be done. Certain factors — extremely good cooperation from the U. S. Forest Service, an above average cone crop, and a good system of roads in the region — made the work easier than can generally be expected. Yet it seems clear that seed collection in Mexica and Central America can be arranged along similar lines.

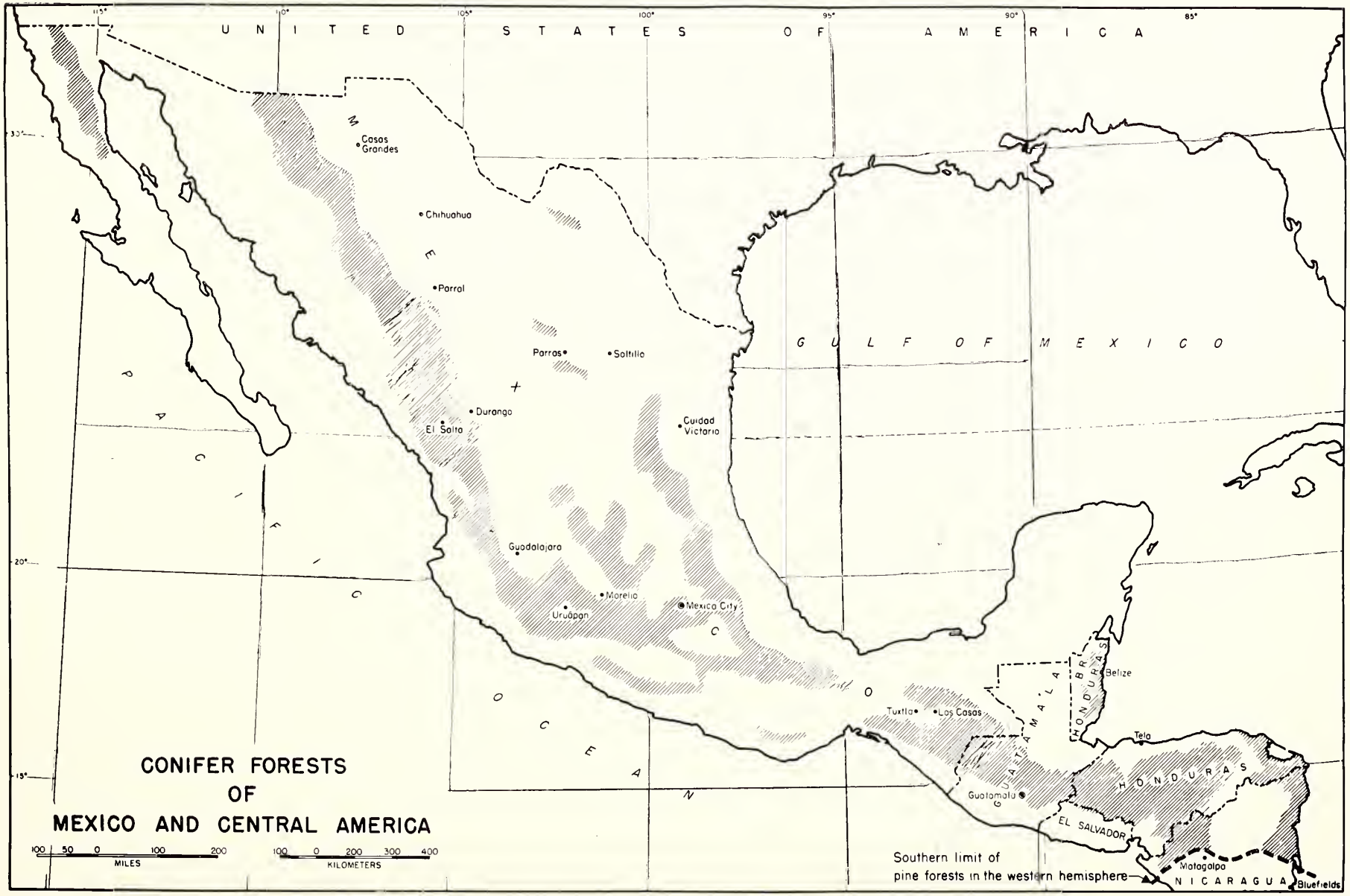
UNITED STATES OF AMERICA
GULF OF MEXICO
PACIFIC OCEAN
CARIBBEAN SEA
Casas Grandes
Chihuahua
Parral
Parras
Saltillo
Durango
El Salto
Ciudad Victoria
Guadalajara
Morelia
Uruapan
Mexico City
Tuxtla
Los Casas
Belize
BRITISH HONDURAS
GUATEMALA
Tela
HONDURAS
Guatemala
EL SALVADOR
Matagalpa
NICARAGUA
Bluefields
Southern limit of pine forests in the western hemisphere
CONIFER FORESTS OF MEXICO AND CENTRAL AMERICA
100 50 0 100 200 MILES
100 0 200 300 400 KILOMETERS

TABLE 1 — SEED COLLECTING CENTERS OF MEXICO AND OF CENTRAL AMERICA

Seed colecting centers	Suggested headquarters	Pine Species
Sonora — Chihuahua	Chihuahua City Casas Grandes Pararl	P. engelmanni, P. arizonica P. ayacahuite brachyptera P. chihuahuana, P. leiophylla
Durango — Sinaloa	Durango	P. engelmanni, P. arizonica P. lumhollzii, P. herrerai P. cembroides
N. E. Desert Rangers (Coahuila, Nuevo León, Tamaulipas)	Saltillo, Parras Cd. Victoria	P. greggii, P. arizonica P. nelsoni, P. pinceana
Michoacan Jalisco	Uruapan Morelia Guadalajara	P. douglasiana, P. lawsoni P. michoacana, P. pringlei P. tenuifolia, P. oocarpa etc.
Mexico, D. F. and adjacent states (including parts of Veracruz)	Mexico, D.F.	P. patula, P. teocote P. rudis, P. hartwegii P. montezuma, P. leiophylla P. ayacahuite
Chiapas	San Cristóbal (Las Casas) Tuxtla	P. montezuma, P. oocarpa P. pseudostrobus P. ayacahuite tipica P. S. chiapensis
Highlands of Central America (Guatemala, Honduras Nicaragua)	Guatemala, Guat., Tegucigalpa, Honduras, Matagalpa, Nicaragua	P. oocarpa, P. hondurensis P. pseudostrobus P. montezuma, P. rudis P. S. chiapensis
Caribbean Coast of Nicaragua Honduras and British Honduras (Belize)	Puerto Cabezas, Nicaragua Tela, Honduras Belize, B. Honduras	P. caribaea

Local Problems of Seed Collecting In Mexico and Central America

It is not an easy task under present conditions to get authentic pine seed (or any other forest tree seed) from Mexico and Central America. One difficulty is the great variability in Mexican pines caused, at least some times, by hybridization among different varieties of a complex species like *Pinus pseudostrobus*. Extreme forms in this complex, that is, *P. pseudostrobus typica* and *P. pseudostrobus* var. *oaxacana* are so different that they could well be called different species. Apparently they cross, and the complex includes all sorts of gradations. Moreover, there are indications that some varieties of *P. pseudostrobus* cross with some varieties of *P. montezuma*. What kind of *P. pseudostrobus* seed would a customer get if be ordered *P. pseudostrobus* seed from Mexico? Many different kinds of pine seeds could be shipped under this name.

Another hazard is the extensive range of some Mexican pines (including the two mentioned). *Pinus oocarpa* is perhaps the best example. It grows in its typical form from southern Sonora to the highlands of Nicaragua. Even if a typical form is specified there is no guarantee that the whole shipment had been collected in the same place. Disaster might result if the shipment were composed of seeds gathered in different localities of its range.

Of course, there is the ever-present problem of correct identification of trees. This is not an easy job when cones are harvested in a mixed pine forest composed of five or six different species. The laborer is always tempted to pick as many cones as possible, disregarding their identity.

Still other problems arise in collecting and handling the cones. Climbing trees calls for equipment that is not easily available. Seeds have to be extracted at some centrally located place, and good supervision is essential at an extraction plant to avoid damaging the seed by heat and moisture or mislabeling the seed lots. Furthermore, to collect cones in the forest, one has to have a permit from the local forest authorities. Mexican forest laws are very strict, and a seed collector should familiarize himself with these laws. Then last, but not least, to ship the seed, there are different kinds of permits to be obtained, customes rules, quarantine regulations, unavoidable delays, etc. All these formalities are time consuming.

Preliminary Studies

It appears desirable that, before establishing a permanent seed collecting agency in Mexico-Central America, an expedition be sent to different forest regions of Mexico and Central America for preliminary survey of seed collecting possibilities, and at the same time to collect seed for establishment of provenance and species trials in the countries that are interested in these species.

This work could not be done by one man, however, and surveying all the important forest regions of Mexico and Central America in one season would probably require more than one party. A party should consist of a botanist who is familiar with the Mexican pines, and a forester who is familiar with cone collection and seed extraction work. Three or four helpers should be aavilable to climb trees for cones and botanical specimens. After a brief check of the material by the botanist to assure that correct species is being dealt with, material and cones could be shipped to a central place for extraction and cleaning of the seed. The botanical specimens would form an excellent basis for a study of the morphological variation in Mexican and Central American pines. It would also be possible to take wood specimens and ship them to a testing station.

As important as it is to have the services of a qualified botanist on such a mission, it

cannot be strongly enough emphasized that a practical-minded seed collector is essential. Seed collection may appear to be a simple and easy task, but on the scale outlined here it requires careful organization and experience (and a good physique).

It is obvious that an international organization would be in the best position to arrange such an expedition.

Permanent Organization

The next step, it seems to us, is establishment of a permanent seed handling agency. Such an agency should be organized by the FAO branch of the United Nations, but run by the Mexican and Central American departments. An international organization would be able to draw experts from all parts of the world. When the agency is organized and well run, sufficient seeds could be collected to supply all interested countries. A central office of the agency should be established, probably in Mexico City, and several branch offices, at least one in each forest region. The central office could organize both seed collection and handle collection of pollen of forest trees for breeding purposes. If a country needs seeds of pines or any other forest trees, the request should go to the central office, which should then forward the request to an appropriate branch office. If the problem is difficult, a specialist should be sent from the central office to help local seed collectors.

Local foresters would be competent to organize cone collection, to supervise the seed extraction, and to certify seeds as to their identity, purity and germination capacity. Yet a great deal of organization work has to be done before a seed collecting agency would function properly. Men are to be trained to climb the trees and gather cones, to dry these, to extract seeds. Time of cone and pollen harvest has to be ascertained for each major species. All these (and many other) activities require a considerable initial expense. But when a seed agency is functioning well, it would be a profitable enterprise. It would give a substantial income to local people, it would provide jobs for many trained Latin American foresters and rangers; and it would be of great benefit to the countries that need seeds of Mexican and Central American pines for reforestation.

NOTE—Conference on Pines of Mexico: FAO and the government of Mexico plan to hold a conference for world foresters in Mexico during September or October 1960 on the pines of Mexico. This will be right after the 1960 World Forestry Congress to be held in Seattle, Washington, U.S.A.

The Cajaput Tree in Florida

By: ELBERT A. SCHORY, SR.
Tropical Research Branch Assistant
Florida Forest Service

HISTORY

Melaleuca leucadendron, commonly called Cajaput, Paper Tree, or Punk Tree, was first introduced to the East Coast of Florida in 1906 by Dr. John C. Gifford. In 1912 seeds of this species were also imported from Australia by A. H. Andrews and planted at the Koreshan Unity on the lower West Coast.

There are numerous species of the genus *Melaleuca* now growing in Florida but most of them are purely ornamental, resembling the *Callistemon* or Bottle Brush, to which they are closely related.

Fig. 1 - Young stand of cajaput showing form and dense cover on wet site. By highway of Estero, Florida.

GENERAL CHARACTERISTICS

Cajaput is a timber tree which has spread from the early plantings referred to above until it covers several hundred acres, mostly

in lower Lee County. The tree is well adapted to the low, wet, sandy soils as shown by the fact that in many places it is actually crowding out the native baldcypress *Taxodium distichum* (L.) Rich. On these sites it grows rapidly and in dense stands develops relatively straight, clear stems. (Fig. 1).

Unfortunately cajaput does not confine itself to these areas but also reproduces itself on the adjoining drier sites where it crowds out slash pine, (Fig. 2) thus sometimes causing it to be considered a weed tree. While no actual growth studies have been conducted, it is evident from casual observation that on these drier and poorer soils the growth is inferior both in size and form. Under favorable conditions in its native habitat in Western Australia, the tree is reported to reach a height of 80 feet and a diameter of 3 feet. However, in Queensland (Eastern Australia) Swain, reported it as "usually seen as a tree of 40 feet in height and as many inches in girth." Growing as it does under a wide variety of soils and climatic conditions, this variation is not surprising.

Most of the available information concerning the wood comes from Australia. Swain sets forth the characteristics as follows: "The wood when air dried weighs about 46 pounds per cubic foot, is compact, even, fine, and short grained—pale pinky-brown hue. Tough and firm to cut, the wood has the defect of brittleness, and this defect increases with age". Nearly every reference mentions that the wood is quite durable, both in and out of the weather, especially in moist

Fig. 2 - Cajaput taking over pine site. Lee County, Florida.

locations. It is evidently also quite resistant to termites.

Like many fast growing hardwoods, the timber is inclined to check and warp in seasoning. Quarter-sawing and seasoning slowly under cover are recommended as preventive measures. There is also the possibility that kiln drying could overcome this characteristic.

MECHANICAL CHARACTERISTICS

Five small logs, the largest having a top diameter of 8 inches, were sent to the U.S. Forest Product Laboratory at Madison, Wisconsin for standard machine tests. Being small, they were found to be full of small knots and no clear test material was obtained from them. Even so, the results were very favorable, being above the average of the native U. S. utility hardwoods and comparing favorably with furniture woods. Results of the specific tests with two native species included for comparison are shown in Table 1.

TABLE 1 — PERCENT OF DEFECT-FREE PIECES

Test	Cajaput	Black Walnut	Sweetgum	Av. for 25 U.S. Species
Planing	60	62	51	61
Shaping	50	34	21	25
Turning	90	91	86	79
Boring	80	100	92	89
Mortising	70	98	58	70

USES

Lumber

As might be expected with a wood of this description, it is highly recommended for furniture and cabinet making, especially the smaller items and for flooring where short lengths can be utilized advantegeously; the Sawmillers Association of New South Wales, Australia has recommended it for this purpose.

R. T. Baker, Lecturer on Forestry, Sydney University, had this to say:

> A pale, delicately tinted, light brown wood, one of the finest timbers in the museum. It is hard, yet light in weight, dresses easily, polishes well, has a nice, close grain and even texture, while its color gives it rank as an excellent cabinet timber, and so is one of the best all-round timbers of the Continent; obtainable in fair-sized logs, and could thus be used for bridge decking, boat knees, beams, piles, etc. as it is very durable in the ground and in the water, for which it is especially recommended. Having no pronounced sapwood and being free from borers, it, therefore cuts up with little waste. It is a splendid timber for gun stocks and carvings, the texture giving a sharp arris.

In addition to the uses mentioned above, long lengths of clear lumber can be used for almost any purpose from framing to trim in the boat industry. On the other hand, the

short lengths and odd sizes, including some of the limbs could be used to advantage by the South Florida novelty and souvenir manufacturers.

Minor Uses

In many localities in South Florida the cajaput has become a favorite tree for landscaping and for this purpose has much to recommend it. It can be grown on a wide range of soils from high-dry to low-wet and on saline soils. Planted closely together for windbreaks it withstands hurricanes well; it can be pruned into a hedge or grown in the open. When open grown, it has a tendency to branch. With its distinctive white bark and often twisted limbs it has a rugged beauty. (Fig. 3).

These same characteristics recommend it for use in pasture as a windbreak and shade tree. One big advantage in its use here is that it is not necessary to fence the young

Fig. 3 - Typical landscape specimen of cajaput, showing attractive bark and branching habit.

Fig. 4 - Natural reproduction of cajaput. Estimated age, 5 years.

trees as livestock do not ordinarily browse them. Another point in their favor is that they are not readily destroyed by fire. On the other hand, it should be born in mind that there is danger of the tree spreading to areas where it is not wanted and thus become a problem. This is especially true on low, wet ground.

The young trees are readily cut into post material and it is rpeorted that in Australia untreated posts stand up well on low, wet ground. This has not been verified in the United States. In an experiment, conducted by the Florida Forest Service, untreated green sapling posts used in fence construction on a dry sand ridge were serviceable after three years.

Cajaput oil, a standard pharmaceutical product, has been produced from the leaves but labor costs make commercial production unprofitable.

The bark of this species, composed as it is of many layers of fine, papery material has had many suggested uses. In Australia the bark, after shredding, is used to stuff mattresses and pillows, partly because it is naturally mildew resistent. A plastics manufacturer found the bark suitable as a filler.

Pulpwood

When considering the possibilities of this wood for cellulose and pulpwood production in South Florida there are a number of factors to be taken into consideration: (1) there is no market for material of this kind at present, (2) the supply is very limited, (3) the wood pulp produced is not desirable for the manufacture of Kraft papers because, like most hardwoods, the fiber is very short and hence lacks tear strength (4) it is a long haul by rail to the nearest mill.

On the other hand, the material is readily available and on moist sites the young trees grow in dense stands of fairly straight, clear poles of a convenient size for handling. This is perhaps the most attractive feature from the pulwood standpoint. Growing as densely as it does, however, creates a felling problem.

Although there is currently no pulpwood market for hardwoods of any kind in Florida, there are indications that the future may be brighter. A private report reveals that pulpwood production in the South may be expected to double by 1975. The additional pulpwood to meet the added requirements of the mills is expected to come from three sources in relatively equal amounts: (1) increased growth of pine, (2) increased use of waste materials, and (3) increased use of hardwoods. That this trend is already in evidence in some southern mills is indicated by the following statement by Mr. E. L. Demmon, retired Director of the Southeastern Experiment Station of the U. S. Forest Service:

> The southern pulp industry uses more hardwoods in its processes every year. For the South as a whole, this ammounted to about 12 percent in 1953. Although limbiness, tight bark, weight, distribution and variety of species make hardwoods somewhat more costly to handle than pine, they offer certain advantages, particularly when semi-chemical pulping is used. With this process, one cord of hardwood will produce about a ton of pulp, whereas with the sulphate process an average of 1-3/4 cords of pine is needed per ton of pulp. Improved techniques have been developed for pulping hardwoods, and the use of southern hardwoods for pulp will undoubtedly increase during coming years.

There are two mills in the State of Florida that are now producing cellulose, for which use length of fibers is not important. It is understood that one of these plants is basically prepared to utilize hardwoods. When this becomes a reality, there is no ap-

parent reason why cajaput cannot be used along with the other hardwoods. While some difficulty may be experienced in removing the bark of the cajaput, this can probably be compensated for by selling the bark as a by-product.

MARKETS

As previously stated, there is no commercial market for cajaput in the United States at the present time. This may be due to the limited distribution of the species since the same thing is true in certain sections of its native Australia. However, a developing market may encourage sufficient volume of raw material, and once the wood is produced in commercial quantities it should compete favorably with imported and native species of similar characteristics.

CONCLUSIONS

Advantages Wood is attractive, machines well, and has some resistance to rot and termites. The tree grows on wet land, is straight and fast growing. It is apparently resistant to fire, disease and browsing.

Disadvantages Has possibility of becoming a weed tree. It is small; the wood comes in short pieces; it is short grained; has a tendency to warp and check with seasoning; and becomes progressively brittle with age.

Suggested uses Flooring, trim, furniture, boat building, novelties, field crates, general construction, landscaping and windbreaks.

The above information will perhaps appraise the present status of the cajaput tree in Florida. What the future holds for it, only time will tell. It is asking too much to expect a new species to receive instantaneous universal acceptance, but in this instance there is good reason to believe the species could be a valuable addition to the economy of South Florida.

LITERATURE CITED

Swain, E. H. F. 1928. The timbers and forest products of Queensland. Queensland Forest Service. 500 pp.

Baker, R. T. 1919. The hardwoods of Australia and their economics. Technological Museum of Tech. Ed. New South Wales. Series 23. 522 pp.

Indicaciones para la Repoblación Forestal de las Fincas de Puerto Rico

Por: JOSE MARRERO Y FRANK H. WADSWORTH
Centro de Investigaciones Forestales Tropicales
RIO PIEDRAS, PUERTO RICO

El Público de la isla, incluyendo gran parte de los técnicos agrícolas, tienen una idea muy vaga sobre nuestro problema forestal o si en realidad existe tal problema. Se han preparado informes describiendo en detalle lo que se considera un serio problema de conservación de recursos naturales, pero dichos informes son conocidos solamente por un estrecho círculo de técnicos. Este artículo tiene por objeto presentar información para uso del público basado en los informes arriba mencionados y en datos de los archivos del Centro de Investigaciones Forestales Tropicales del Servicio Forestal Federal y orientada a contestar las siguientes interrogaciones:

1. ¿Porqué es indispensable aumentar el área forestal de la isla?

2. ¿Cuáles serían las áreas a repoblarse y las probables maneras de enfrentar el problema?

3. ¿Cuáles son las especies que hasta la fecha se han encontrado más adaptadas a los distintos terrenos forestales de la isla y en qué época es preferible hacer las plantaciones?

La contestación a la última interrogación es puramente de carácter técnico y pocas veces se ha presentado en una forma organizada a los técnicos relacionados con las plantaciones forestales tales como oficiales de los servicios forestales, agentes agrícolas, maestros de agricultura vocacional y otras personas directamente relacionadas con el trabajo de repoblación forestal. La información que se presenta es producto de reconocimientos, estudios e investigaciones realizados durante varios años y esperamos que supla la información necesitada para la mejor ejecución de las labores de repoblación.

AREAS FORESTALES Y SUS PROPOSITOS

Los dos millones y pico de cuerdas que encierra la isla de Puerto Rico estuvieron casi totalmente cubiertas por bosques. Se sabe que la población indígena apenas hizo mella en los bosques. Sin embargo, desde que se inició la colonización de la isla los bosques han sido gradualmente y repetidamente destruídos para dedicar las tierras a cultivos agrícolas, para pastoreo, para localización de pueblos, ciudades y caminos, de manera que en la actualidad quedan menos de 500,000 cuerdas cubiertas de bosques y malezas e incluyendo las arboledas de café. Se calcula que de los bosques destruídos, sólo se utilizó un 20 por ciento 1/ y el resto se quemó y desperdició. Excepto unas 90,000 cuerdas incluídas en los bosques públicos, insulares y federales, los cuales incluyen bosques de valor, el balance incluye bosques de poco valor productivo.

El desmonte de terrenos de valor permanente para agricultura se justifica. Sin embargo, existe mucho terreno de escaso valor agrícola y que por su naturaleza debe conservarse bajo arboleda, que en la actualidad está deforestado y no rinde gran provecho. Las cosechas de cultivo limpio, muchas de las cuales son de gran rendimiento, no pueden producirse continuamente en terrenos

1/ A Comprehensive Agricultural Program for Puerto Rico, N. Koening, Departamento de Agricultura Federal, pag. 105.

muy inclinados debido al peligro de la pérdida de suelo por erosión.

Debido a la topografía montañosa de la isla se estima que el terreno accidentado sobre 50 por ciento de pendiente (casi todos sobre el 60 por ciento) llega a unas 691,000 cuerdas, 2 . Otras áreas de uso limitado que no pueden o no deben dedicarse a cultivo limpio por otras razones como la de ser rocosas, muy húmedas, muy secas o estériles y por haber disponibles otras tierras más apropiadas para la producción de cosechas agrícolas y para satisfacer nuestras necesidades llegarán a unas 368,000 cuerdas. 3 Sumando estas dos categorías se ha llegado a la conclusión de que más de un millón de cuerdas o casi la mitad de las tierras de la isla no se prestan para cultivos limpios

Las cosechas llamadas protectoras o sea que no requieren la labranza o cultivo del suelo serían las llamadas a cultivarse en esta mitad de la isla que no se presta para cultivos limpios. Dichas cosechas protectoras incluyen el café, el forraje y los bosques. Las dos primeras cosechas donde pueden cultivarse en la actualidad aparentemente pueden dar mayor rendimiento que la producción de madera, pero son más exigentes en sus requerimientos. Los estudios ya mencionados indican que del millón aproximado de cuerdas que no se prestan a cultivos limpios unas 520,000 cuerdas aproximadamente podrían dedicarse a la producción de forraje y de café. El resto como de 540,000 cuerdas que no se necesitan o no se prestan para otros cultivos, podrían dedicarse a bosques sin detrimento alguno para la producción de otras cosechas y bajo un plan correcto de uso de la tierra. Hoy casi todo el terreno que no se presta a otros cultivos se usa mayormente para un pastoreo extensivo en detrimiento de la conservación de los suelos y del agua.

Conservación de las Aguas

No debemos pensar exclusivamente a base de la producción de productos tangibles de valor monetario como las cosechas, ganado y maderas. El bosque por su influencia sobre el clima y la conservación de las aguas contribuye al bienestar de toda la población de una manera difícil de valorar en términos de pesos y centavos. En este sentido es de más valor que ningún otro uso posible de la tierra.

El Décimoctavo Informe Anual del Centro de Investigaciones Forestales Tropicales discute el problema de las aguas en los siguientes términos:

"Nuestra escasez de agua no se debe generalmente a la falta de lluvia. De los 13,000,000 acrepiés recibidos cada año en Puerto Rico solo 1,230,000, o menos del 10 por ciento, están disponibles como flujo constante de los ríos. Parte de la diferencia se pierde por evaporación, parte es usada por la vegetación (ventajoso dondequiera que se producen productos de valor) pero casi la mitad corre sobre la superficie del terreno durante las lluvias, causando erosión en los suelos y corriendo rápidamente hacia el mar o a lo largo de los ríos. Aunque en estos grandes proyectos de riego se usan anualmente 210,000 acrepiés y aunque tenemos 19 plantas de fuerza hidroeléctrica, no hay la menor duda de que en la actualidad estamos dándole uso efectivo a menos de la mitad del agua que recibimos.

Nuestro verdadero problema es conservar el agua que recibimos hasta que se le pueda dar un uso efectivo. Los aguaceros torrenciales nos proveen con lluvia más rápidamente de lo que es absorbida por el terreno, de manera que corre cuesta abajo sobre la superficie. Esta escorrentía es especialmente fuerte en áreas donde el suelo desnudo recibe directamente el impacto completo de la lluvia, se torna fangosa y obstruye los poros del suelo,

2/ Décimoctavo Informe Anual del Centro de Investigaciones Forestales Tropicales, 1958. Este informe en parte está basado sobre datos publicados y no publicados de la División de Bosques, Pesca y Vida Silvestre, Autoridad de las Fuentes Fluviales y la Junta de Planificación del Estado Libre Asociado de Puerto Rico.

3/ Décimoctavo Informe Anual del Centro de Investigaciones Forestales Tropicales, Servicio Forestal del Departamento de Agricultura de los Estados Unidos.

o donde la superficie del suelo está ya compacta por el intenso pastoreo. Esto sobrecarga los ríos, desborda nuestras represas, el agua corre hacia el mar frecuentemente causando inundaciones en su curso. A esta agua, que viene de repente e inesperadamente en grandes cantidades y cargada de sedimento, es virtualmente imposible darle uso antes de que se pierda. Si se va a almacenar para usarse más tarde, como durante las sequías, serían necesarios inmensos embalses artificiales. Nuestros embalses, costosos e impresionantes como son, solamente tienen capacidad como para 400,000 acrepiés de agua cada año. Además, continuamente pierden su valiosa capacidad de almacenamiento debido al sedimento, que arrastrado por las aguas de escorrentía se deposita en su fondo. La mejor forma de conservar nuestras aguas es almacenando más de ellas en ese embalse natural que es el suelo. El agua que penetra el suelo, distinta de aquella que corre por la superficie hacia el mar, necesariamente no se pierde ni causa erosión. Mientras está cerca de la superficie está disponible para ser absorbida por las raíces de las plantas. A mayor profundidad se filtra poco a poco hacia manantiales naturales o está disponible para sacarse de los pozos, en ambos casos clara y accesible tanto durante períodos de sequía como lluviosos. *Esta es en realidad agua útil.* Su almacenamiento solo exige el mantenimiento de una cubierta porosa y receptiva en la superficie del terreno. Esta cubierta puede mantenerse mejor por medio de una capa de vegetación contínua y densa sobre una capa de hojarasca directamente sobre el terreno. De todas las cosechas el bosque es el mejor que satisface estos requisitos.

El sitio para conservar nuestra agua es en las montañas, que reciben lluvias intensas y donde a causa de laderas inclinadas la escorrentía es más probable, y donde se le puede dar mayor variedad de usos al agua almacenada debido a su elevación. Las áreas que producen más agua casi coinciden con aquellas áreas, ya definidas, donde una cubierta vegetal es necesaria para proteger también el suelo."

Producción de Madera

Aquellos terrenos donde el único interés sea la conservación de las aguas, de la vida silvestre o meramente conservar el ambiente forestal, no requieren que se establezca en ellos plantaciones forestales. Si ya poseen malezas éstas seguirán creciendo con solo evitar por completo el pastoreo y el cultivo. La conservación de las aguas y la vida silvestre se logra en poco tiempo dejando crecer la maleza aun sin sembrar árboles, y lo que es muy importante, no requiere desembolso alguno excepto para establecer cercas para la protección contra el ganado. Sin embargo, la economía de la isla requiere que aquellos terrenos que puedan producir productos forestales lo hagan, para lo cual en muchos casos es necesario recurrir a la siembra.

El informe arriba mencionado considera que no más del cinco por ciento de la superficie de la isla está cubierta por bosques maderables. El resto de los bosques contiene pocas especies de árboles por lo general consideradas valiosas, y casi ningún árbol grande. Los árboles que ahora se cortan generalmente son usados y desperdiciados porque no se aprecia por completo el valor de su madera. Solamente una pequeña parte de la producción de nuestros bosques se utiliza en parte debido a que los costos a que se obtienen dichos productos resultan muy altos debido a extracción deficiente, aserrado pobre, secado inadecuado y falta de facilidades de mercadeo.

No hay duda de que es necesario producir más madera si se puede hacer adecuada y económicamente. La isla importó en el año 1957 productos forestales por valor de $39,300,000 [4/] equivalentes a una importación per capita de $17.04. Esto incluye tales artículos como madera, "plywood", cajonería,

4/ Estadísticas de Comercio Extranjero, Negociado de Economía y Estadísticas, Junta de Planificación de Puerto Rico, 1957.

mangos de herramientas, puertas y ventanas, postes, pilotes, productos de papel y otros. Producimos todos los postes de cerca y toda la leña y carbón consumidos que son los productos de más volumen pero menos valiosos. Los principales productos maderables alcanzan un volumen de cerca de 100.000,000 pies tablares, además de grandes cantidades de muebles fabricados, papel y otros productos.

Una de las principales interrogaciones es la cantidad de madera que podríamos producir. El informe del Centro de Investigaciones, ya mencionado, especifica que deben dedicarse a la producción de madera toda aquella parte de las 500,000 cuerdas de terreno propiamente forestal donde sea económicamente factible y de resultar insuficiente esta área podrían producirse dentro del millón de acres de terreno que no permite cultivo limpio o en cualesquiera otras tierras donde la producción de madera rinda más que las otras cosechas.

El informe mencionado ofrece datos de los productos forestales que podrían lograrse dentro de las áreas críticas que requieren protección forestal.

TABLA 1 — EXTENSION Y PROBABLE LOCALIZACION DE LOS TERRENOS FORESTALES PROPIOS PARA LA PRODUCCION DE MADERA

Productos	Región de terrenos forestales	Areas más propias dentro de los terrenos forestales
		miles de cuerdas
Papel	Suelos lateríticos	28
	Suelos lómico-arenosos	9
Muebles	Zona caliza húmeda	56
	Suelos arcillosos profundos	42
Postes para cercas	Manglares	9
Arboles de Navidad	Suelos lómico-arenosos profundos	1
Cabos de herramientas	Suelos lómicos poco profundos	8
Pilotes y postes	Suelos lómico-arenosos profundos	17
Cajonería	Suelos lómicos poco profundos	12
Total		182

Sitios de Recreo

A pesar de que los paisajes de las montañas de la isla son de gran belleza escénica, están desprovistos de árboles. Su repoblación forestal sin duda aumentaría considerablemente su atractivo como sitio de recreo. El éxito y la demanda de tales centros de recreo pueden apreciarse por el gran éxito de la famosa área recreativa de la Mina en el Yunque en el Bosque de Luquillo, visitada durante el año 1958 por 169,000 personas, lo que trajo una inversión de unos $417,000 por los visitantes lo cual pone una valoración mínima de $9,500 por cuerda en el área recreativa sin incluir, desde luego, las entradas por los servicios que se puedan proporcionar al visitante. El Centro ha calculado que se necesitarían unas 12 áreas, cada una con una área de 40 cuerdas, a lo cual se le calcula un valor equivalente en dinero a cerca de $850,000 anuales para servir a la población actual y a los turistas. En el futuro las facilidades recreativas habrían de ser aumentadas para servir a una población mayor de residentes y turistas.

REPOBLACION DE LA FINCA

Una de las mayores interrogaciones es quién y de qué manera se realizará la repoblación del área que por carecer de arboleda habría que repoblar artificialmente. Ya hemos expuesto que los bosques públicos incluyen en total unas 90,000 cuerdas las cuales están prácticamente cubiertas por bosques. Por lo tanto, el grueso del área a repoblar se encuentra en las fincas particulares.

La zona cafetalera la cual incluye una área considerable que se calcula en por lo menos 160,000 cuerdas, ofrece el mejor ejemplo de como se podrían repoblar otras áreas. La gran obra de repoblación con árboles de sombra y de café se hizo debido al incentivo económico que ha representado el cultivo del café. Comprendemos que el área total a repoblar es aún más extensa y que habría problemas de mano de obra que no existieron al establecer las plantaciones de café.

El incentivo para la reforestación sería de dos tipos:

1. Ganancia que se derivaría por el cultivo de cosechas forestales.
2. Incentivos monetarios públicos como contribución para la repoblación y para la protección de las plantaciones por daños ocasionados por el ganado, etc.

Actualmente las siembras de especies forestales se hacen de especies que el agricultor necesita en la explotación de la finca tales como varas y postes en aquellas zonas donde no se consiguen árboles naturales espontáneos en la finca. Naturalmente, estas siembras se hacen en pequeña escala solamente para satisfacer las necesidades de la finca. Cuando existan especies comerciales cuyo cultivo pueda hacerse remunerativamente en rotaciones cortas, posiblemente para uso industrial, entonces se podría generalizar la siembra de árboles en una escala de tal magnitud que afecte zonas extensas de la isla. El desarrollo industrial debe proveer mercado para absorber dicha materia prima producida en la isla.

Actualmente existe en Ponce una industria que absorbe gran parte de la producción de madera de yagrumo hembra de la zona cafetalera y hay otras industrias que podrían utilizar mayores cantidades de madera si se produce a precios convenientes. La fabricación de papel y cartón a base de bagazo de caña, para lo cual pronto operará una fábrica en Arecibo, requiere el uso de pasta de madera de pino para mezclar con el bagazo. Hay además otras industrias ya establecidas que podrían usar maderas producidas en la finca. Mientras que en las cosechas tradicionales de caña, café y tabaco existe exceso de producción mundial y por lo tanto, mercados deprimidos, en los productos forestales hay una mejor perspectiva por estar la producción y el consumo mejor balanceados.

En relación a los incentivos monetarios

que paga el gobierno, se calcula que en la actualidad el agricultor recibe como la mitad de los gastos en que incurre en la siembra y en cercar las plantaciones. Durante el año 1958 ciento veinte terratenientes recibieron pagos de compensación por prácticas forestales por un total de $5770. Otro de los incentivos incluye demostraciones y asesoramiento técnico y exención contributiva por la Ley Núm. 43 del año 1934.

Las principales cosechas agrícolas reciben fuertes subsidios y ayuda gubernamental como en el caso del café, tabaco, y caña de azúcar. Es lógico que para competir con otras cosechas será necesario que el gobierno subvencione fuertemente el cultivo de plantaciones forestales, especialmente durante la etapa inicial del desenvolvimiento de las plantaciones. El gobierno tiene un marcado interés en promover la producción de materia prima que sirva de base para su extenso programa industrial e indudablemente daría toda la ayuda posible.

HISTORIA DE LA DISTRIBUCION DE ARBOLES A TERRATENIENTES

El programa de distribución de árboles a terratenientes, a otras agencias del gobierno, a amas de casa y a asociaciones interesadas principió en el año 1921 y se ha continuado hasta ahora. La cantidad distribuída aumentó gradualmente hasta un total de dos millones anuales la que se ha reducido en los últimos años hasta cerca de la mitad de esta cantidad. En total se calcula que se ha distribuído al público unos 65 millones de arbolitos, suficientes para repoblar unas 94,000 cuerdas. Sin embargo, un inventario reciente demuestra que el área de plantaciones es insignificante y no excede del 3 por ciento del área que se suponía sembrada. Parte de esta discrepancia se debe a que algunos de los árboles han sido cortados para utilizarse. Sin embargo, gran parte de la diferencia se explica solamente por el fracaso de las siembras debido a tales causas como (a) selección impropia del sitio a sembrar; (b) tiempo poco favorable; (c) árboles entregados pero nunca sembrados y (d) protección inadecuada de los árboles contra la competencia de los yerbajos, del pastoreo del ganado, destrucción intencional, etc., todo lo cual es el resultado de la falta de supervisión de las plantaciones después de establecidas. Sin duda alguna éste ha sido un programa costoso, específicamente si se consideran los resultados obtenidos. El valor de los árboles solamente pasa de $300,000 sin contar los gastos de transporte, gastos generales, etc. todo lo cual hace subir el costo considerablemente.

Para evitar la repetición de tales resultados se organizó un programa llamado Programa Cooperativo de Manejo Forestal en la División de Bosques, Pesca y Vida Silvestre del Departamento de Agricultura y Comercio, que dispone de personal de campo que supervisa el trabajo en las fincas y decide cuales agricultores pueden acogerse al programa, cantidad y especie de árboles a sembrar y organiza y supervisa la distribución de los árboles. Este programa durante el año 1958, su tercer año de existencia, distribuyó 427,000 árboles con una supervivencia de sobre 85 por ciento, un gran adelanto sobre el programa anterior de distribución sin supervisión.

Principiando con una área que incluía cinco municipalidades, el programa cubre en la actualidad doce municipalidades y seguirá extendiéndose gradualmente según lo ameriten las circunstancias. Se ha demostrado que existe gran interés entre los terratenientes por establecer plantaciones forestales y que se pueden lograr buenas plantaciones en un programa bien organizado que supervise sobre el terreno la labor de reforestación. La demanda por árboles continúa en aumento como resultado de todos los aspectos del programa de repoblación incluyendo las fases educativas, la mejor supervisión en la finca, atractivo de los incentivos y mejor organización de la distribución de los árboles. Tal demanda ha sido dramatizada en la celebración del centenario del nacimiento de Muñoz

Rivera por medio de un programa de siembra de árboles de no menos de un millón de árboles. Un aumento en el uso industrial de árboles cosechados en Puerto Rico sin duda alguna requeriría que se multiplicara el número de árboles a sembrarse. Todo ésto hace vislumbrar un aumento gradual o quizás momentáneo en el trabajo de repoblación en las fincas.

ADAPTABILIDAD DE LAS ESPECIES FORESTALES A LOS DISTINTOS SITIOS

Uno de los puntos donde es más deseable ofrecer información es sobre las distintas especies que crecen mejor y son más productivas y en qué sitio de la isla deben sembrarse preferiblemente. También falta información precisa sobre la época del año más apropiada para la siembra en cada localidad. En primer punto llamamos adaptabilidad de especies a las distintas zonas. Existen datos sobre la adaptabilidad de gran número de especies pero presentaremos datos preferiblemente de las especies que están siendo distribuídas de los viveros del gobierno. Si el número de estas especies distribuídas aumentara habría que enmendar la lista de acuerdo. Las especies que crecen natural o espontáneamente en los distintos sitios y que no están incluídas en esta lista, lógicamente no se consideran porque su presencia espontánea en un sitio demuestra que se dan bien aunque en algunos sitios crecen mejor que en otros.

Se puede decir que la adaptabilidad de la especie al sitio es la clave del éxito, es decir, si la especie está bien adaptada al ambiente, mayormente al clima y al suelo, el éxito está asegurado a menos que intervengan cataclismos o sucesos tales como incendio, daños por el hombre o animales y ataques por insectos y enfermedades que destruyan la planta. En todos los países se cometen errores en querer adaptar especies a sitios poco propicios, lo cual a menudo es la razón por el fracaso de programas de repoblación en distintas escalas desde la pequeña siembra en una finca particular hasta los ambiciosos programas en escala nacional con la consiguiente pérdida en dinero y en entusiasmo.

La mayor parte de las especies introducidas que tienen éxito son especies muy adaptables o sea que soportan gran diversidad de condiciones, aun condiciones adversas. Buenos ejemplos son casuarina, cassia de Siam, cassia amarilla, caoba, guamá venezolano, samán y otras. Otras especies sin embargo, se dan bien dentro de un límite más estrecho de condiciones donde pueden ser muy prometedoras, por ejemplo, en Puerto Rico el eucalipto crece muy bien en las mayores elevaciones en un clima lluvioso y más fresco pero cerca de la costa crece por un tiempo y luego languidece. De la misma manera en sitios secos y adversos algunas especies como por ejemplo la caoba de las Antillas se da muy bien al igual que un número reducido de especies, pero gran parte de las especies de ambiantes más favorecidos al sembrarse en estos sitios adversos si sobreviven crecen poco saludables y claramente fuera de sitio.

No debe confundirse la sobrevivencia durante un período después de la siembra, con la adaptabilidad. Son cosas distintas. La sobrevivencia es el resultado directo de la siembra y de los distintos factores de la siembra tales como reacción de la especie, tipo de siembra (si a raíz desnuda o con pilón), cantidad de lluvia al tiempo de la siembra, cuidado y método de sembrar, precauciones, etc. La adaptabilidad de la planta es su reacción después de establecida a los factores de clima y suelo que se explican a continuación. Por lo tanto, una planta puede estar perfectamente adaptada al medio, por ejemplo, un arbusto de café que sembrado en un ambiente favorable, digamos como en Utuado y Jayuya, sucumbe al trasplante. En caso contrario bien sea por su habilidad de trasplantar bien y por otras circunstancias favorables, una planta no adaptada al medio puede sobrevivir ciento por ciento y luego gradualmente desaparecer por falta de ajuste

al ambiente, mostrando así su falta de adaptación.

A veces la condición del suelo es un factor determinante en la adaptabilidad. Los suelos arcillosos en las zonas muy húmedas y más altas de las montañas, por ejemplo, sufren mucho en su condición física y quizás aun en su composición química al desmontarse y dedicarse al cultivo y al pastoreo irracional y se convierten temporeramente en lo que llamamos suelos degradados. Sin embargo, el roble nativo coloniza tales suelos y al sembrarse se da con gran lozanía, y es capaz de competir ventajosamente con la maleza y yerbajos que invaden dichos suelos. Otras especies más exigentes al sembrarse en tales condiciones desaparecen al poco tiempo en parte al no poder desarrollar con la lozanía y rapidez necesarias para competir con los yerbajos.

En Puerto Rico como en todos sitios, hemos sufrido las consecuencias de la falta de información y la siembra de muchas especies "fuera de sitio" ha sido una de las principales razones por el fracaso de muchas siembras. Los terrenos forestales públicos, donde fué necesario, han sido repoblados en toda su extensión y actualmente existen unos cuantos miles de cuerdas de plantaciones. Naturalmente, en la realización de esta labor se acumularon datos 5/ los cuales sumados a los que obtuvieron al examinar plantaciones en unas 300 fincas particulares en toda la isla, han proporcionado datos de los cuales hemos derivado las recomendaciones que siguen.

Desde luego, había la necesidad de preparar estos datos, extensos de por sí, en una forma breve y esquemática. Se han preparado lo que hemos llamado tablas de adaptabilidad dando una lista de especies adaptadas a distintas regiones de clima y suelos. Gradualmente estos datos se han simplificado y últimamente han sido combinados con datos de lluvia para dar además la época más propicia para sembrar de acuerdo con el promedio de lluvia para la zona. Hemos encontrado que los factores más influyentes en determinar la adaptabilidad bajo nuestras condiciones son los siguientes: (1) clima, (2) suelos, (3) topografía, (4) declive, (5) orientación y (6) exposición.

Naturalmente, no todos estos factores tienen la misma influencia. Unos son más efectivos que otros y algunos no ha sido posible incluirlos en la tabla por no prestarse a ello. Sin embargo, nos proponemos discutirlos individualmente para explicar el efecto relativo de cada uno.

Los dos factores más importantes del clima o sea la lluvia y la temperatura, no afectan la adaptabilidad de las especies al mismo grado. Siendo nuestro clima tropical y nuestra extensión territorial limitada, las variaciones en temperatura son relativamente de poca importancia y las que hay se deben mayormente a la diferencia en elevación entre el nivel del mar y los cuatro mil y pico de pies que es nuestra mayor elevación. Como en el trópico al ascender 300 pies de elevación la temperatura baja 1°F, la diferencia total entre el nivel del mar y los 3500 pies, el límite de las plantaciones forestales, sería aproximadamente 12°F lo cual no afecta mucho la vegetación ya que aún en las elevaciones más altas la temperatura no es lo suficientemente baja para producir heladas. Sin embargo, cualquier diferencia que hubiere se consideraría ya que existe una categoría aparte para la zona sobre los 2200 pies de elevación.

El factor lluvia es de mucha importancia por que existe una gran variación entre los sitios más áridos con menos de 30 pulgadas de lluvia anualmente en promedio y los más lluviosos con un promedio anual de 180 pulgadas. Los sitios más secos sufren de sequías más prolongadas e intensas. Basados

5/ Forest Planting in the Caribbean National Forest, Past Experience as a Guide to the Future, José Marrero, Caribbean Forester, Vol. 9, No. 2, April 1948. Results of Forest Planting in the Insular Forests of Puerto Rico, José Marrero, Caribbean Forester, Vol. 11, No. 3, July 1950.

mayormente en la precipitación se ha dividido la isla en tres grandes zonas a saber: (a) costa húmeda que recibe entre 60 y 80 pulgadas anualmente; (b) costa seca que recibe entre 30 a 60 pulgadas y (c) la montaña, todo el terreno hacia el centro y sobre el contorno de los 500 pies de elevación.

En cuanto a los suelos se ha reconocido que la profundidad es de gran importancia en determinar la adaptabilidad y se han establecido dos categorías: suelos poco profundos y suelos profundos como subdivisiones de las zonas geográficas arriba mencionadas. Los suelos profundos se consideran aquellos donde existe una profundidad de 18 pulgadas o más entre la superficie y la roca madre e incluyen los suelos pesados en las zonas más húmedas de la Cordillera Central, de la Sierra de Cayey y en la mayor parte de las montañas de Luquillo. Los suelos menos profundos incluyen la mayor parte de las vertientes este y sur de la Cordillera Central y las vertientes oeste y sur de la Sierra de Cayey. En la costa los terrenos poco profundos son derivados de la roca caliza. Bajo cada uno de los grandes grupos de suelos se ofrecen las series de suelos más importantes lo cual ayuda grandemente a la localización de los suelos.

El factor topografía es uno de los de mayor importancia y como tal se presenta en la tabla. Se considera que la topografía es el factor aislado (fuera del clima) de mayor influencia sobre la adaptabilidad de especies en los terrenos accidentados de las montañas.

Las condiciones ambientales son más favorables en las depresiones y en los valles y menos favorables hacia la cima o las cumbres o sea más favorables en la ladera cóncava que en la ladera convexa. Se han separado entonces dos sitios diferentes o sea la ladera cóncava o valle y la ladera convexa o cimas y cerros. En muchos casos se ofrece un sitio intermedio entre estos dos que consiste en la ladera que une estos detalles topográficos y se incluye sencillamente como ladera. (Fig. 1).

El drenaje es un factor de menor importancia que la profundidad en esta clasificación aunque puede serlo en las zonas más lluviosas donde las áreas planas y de poco declive aparentemente sufren de drenaje pobre. En la tabla de adaptabilidad la única distinción a este respecto se hizo entre los suelos moderadamente a bien drenados donde se realizan la mayor parte de las plantaciones y los suelos pobremente drenados incluyendo los pantanos donde las plantaciones son muy limitadas.

El uso a que se ha sometido la tierra influye mucho sobre las especies que pueden adaptarse. Los terrenos forestales especialmente los terrenos en las localidades más lluviosas se deterioran rápidamente al desmontarse si se dedican al cultivo intenso o al pastareo. Los efectos de la modificación del suelo debido al uso puede afectar el desarrollo de los árboles, por lo menos temporeramente, tanto o más como las condiciones físicas o químicas inherentes del suelo. Por ejemplo, en los suelos pesados en las áreas más lluviosas en las elevaciones más altas de las montañas el éxito de la plantación parece tener una relación más directa con el uso a que se ha sometido el terreno que ningún otro factor, aun más que otros factores como la topografía que se han encontrado ser más importantes en las demás zonas. Expresado brevemente, los suelos de las montañas se deprecian con el uso y a mayor uso menos favorables son las condiciones, lo que reduce el número de especies que pueden adaptarse.

Por razones obvias el factor uso aunque importante es muy variable y completo para incluirse en la tabla de adaptabilidad y es algo que solamente se puede determinar sobre el terreno en cada caso en que hubiere que determinar la adaptabilidad de la especie.

El declive tiene algún efecto en que los terrenos con declive tienen mayor drenaje lo que afecta la retención del agua. Por lo tan-

to, existe una interrelación con drenaje, por lo que en localidades que reciben una precipitación muy alta los árboles crecen mejor en los terrenos inclinados donde el exceso de agua se pierde, en preferencia a los sitios de poco declive que conservan un exceso de humedad. En localidades que sufren por sequía, por el contrario, los sitios muy accidentados a veces sufren por falta de humedad más que los sitios de menos inclinación. Igualmente los sitios accidentados sufren del mismo modo por erosión de los suelos. El factor declive, sin embargo, no está considerado en la tabla porque no es fácil establecer relaciones directas entre distintos declives y adaptabilidad con la base que se obtuvo para este trabajo.

La orientación del lugar es de importancia en los lugares más secos y expuestos y se nota la influencia sobre la vegetación en sitios que reciben como unas 70 pulgadas de lluvia anualmente o menos. Los sitios que dan o están orientados al este y sur están expuestos a los vientos que soplan persistentemente de esa dirección y además están más expuestos al sol, lo que causa desecación debido a una mayor evaporación. Por tanto, en sitios secos se nota una vegetación más exhuberante en las laderas orientadas al norte y al oeste y las plantaciones también desarrollan mejor y con mayor supervivencia. Este factor se ha introducido en la tabla de adaptabilidad en las zonas montañosas más áridas.

Fig. 1 - Una vista panorámica del Interior Montañoso Húmedo (Zona No. 6) mostrando el valle del Río Toro Negro cerca de Ciales. El tope del cerro poblado de árboles a la izquierda de la foto, al igual que los cerros y las laderas al fondo, pertenecen al Sitio No. 6a. El valle y las laderas protegidas que lo circundan pertenecen al Sitio No. 6b. Ambos terrenos, los lómicos poco profundos y los arcillosos profundos están representados.

La exposición se refiere a la cantidad de luz y sombra recibida. La mayor parte de las

plantaciones tienen una mejor supervivencia y desarrollan mejor durante los primeros años bajo cierto grado de sombra. La sombra provee un ambiente más favorable al arbolito por la mayor uniformidad en la humedad y temperatura que le provee, además porque inhibe el crecimiento de bejucos y yerbajos. También los suelos bajo arboleda conservan condiciones físicas y químicas mucho más favorables que los suelos a la intemperie, los cuales generalmente han estado expuestos al proceso de degeneración antes descrito. Según desarrollan los árboles necesitan mayor cantidad de luz aunque en ésto existe gran variación entre muy exigentes hasta poco exigentes. No se trató de clasificar las especies de acuerdo con este factor por no existir los datos correspondientes.

La tabla siguiente muestra una lista de especies forestales adaptadas con sus usos y de interés actualmente para el programa forestal en las fincas.

TABLA 2— LISTA DE ESPECIES ADAPTADAS Y SUS USOS

Nombre Vulgar	Nombre Científico	PROPIA PARA					
		Postes y madera	Cercos vivos	Sombra a lo largo de caminos y cercas y para rompevientos.	Sombra ganado	Sombra café	
Acacia amarilla	Albizzia lebbeck (L.) Benth.	x	—	x	x	—	
Almácigo	Bursera simaruba (L.) Sarg.	—	x	—	—	—	
Bambú	Bambusa sp.	—	—	x	—	—	
Bucare	Erythrina glauca Willd.	—	x	—	—	—	
Bucare enano	Erythrina berteorana Urban	—	x	—	—	—	
Bucayo	Erythrina poeppigiana (Walp.) O.F. Cook	—	x	—	—	—	
Caoba hondureña	Swietenia macrophylla King	x	—	x	—	—	
Cassia de Siam	Cassia siamea Lam.	x	—	x	—	—	
Casuarina	Casuarina equisetifolia L.	x	—	x	—	—	
Ciruela del país	Spondias purpurea L.	—	x	—	—	—	
Emajagüilla	Thespesia populnea (L.) Soland.	—	—	x	—	—	
Eucalipto	Eucalyptus robusta J. E. Smith	x	—	x	—	—	
	Eucalyptus kirtoniana F. Muell.	x	—	x	—	—	
Gliricidia	Gliricidia sepium (Jacq.) Steud.	x	x	—	—	x	Cuba
Guaba del país	Inga Vera Willd.	x	—	—	—	x	
Guamá venezolano	Inga quaternata Poepp. & Endl.	—	—	—	—	x	
Jagüey	Ficus laevigata Vahl.	—	x	x	x	—	
Jobo	Spondias mombin L.	x	x	—	—	—	
Mamey	Mammea americana L.	x	—	x	—	—	
María	Calophyllum brasiliense Camb.	x	—	x	—	—	
Pterocarpus	Pterocarpus indicus Willd.	x	x	x	—	—	
	Pterocarpus marsupium Roxb.	x	x	x	—	—	
Roble	Tabebuia heterophylla (D.C.) Britton	x	x	x	—	—	
Samán	Pithecellobium saman (Jacq.)	x	—	—	x	—	
Teca	Tectona grandis L.	x	—	—	—	—	

SITIOS PARA LAS DIFERENTES ESPECIES FORESTALES

De acuerdo con los datos ofrecidos de antemano en Puerto Rico se han reconocido tres regiones principales y siete zonas de significación a la adaptabilidad y productividad de especies forestales. Muchas de éstas se han subdividido en otras categorías debido a diferencias en la topografía o en el drenaje, resultando en la organización siguiente. Estas zonas se describen a continuación incluyendo listas de especies adaptadas a sembrar en ellas. Los bosques y las malezas naturales generalmente contienen otras especies, muchas de las cuales aun cuando no han dado buenos resultados al plantarse, son de valor y deben conservarse en vez de destruirlas para sustituirlas por árboles sembrados. Las especies subrayadas son las que se distribuyen desde los viveros de la División de Bosques, Pesca y Vida Silvestre del Departamento de Agricultura y Comercio.

COSTA HUMEDA

Se incluye todo el terreno de 500 pies o menos de elevación a lo largo de la costa oeste, norte y este, desde el norte de la municipalidad de San Germán en el suroeste siguiendo a lo largo de la costa norte hasta el Río Patillas en el sureste e incluyendo los valles interiores y toda la zona caliza del norte (aquí se alcanzan elevaciones hasta de 1000 pies o más).

ZONA No. 1 — Terrenos poco Profundos de la Costa Húmeda

Series de suelos: Múcara, Tanamá, Colinas, Soller, Sabana, Naranjito, Yunes, y otras series similares.

Sitio No. 1a - Incluye mayormente el tope de los mogotes calizos
Especies: *maría, roble, casuarina,* almácigo, jagüey

Sitio No. 1b - Laderas expuestas a los mogotes (debido a condiciones un poco más favorables se presta a un mayor número de especies que el Sitio 1a)

Especies: *maría, roble, casuarina,* jagüey, almácigo, *gliricidia,* mamey, cassia de Siam

Sitio No. 1c - Laderas protegidas y abras (valles)
Especies: *caoba hondureña, maría, teca, casuarina, gliricidia,* jagüey, bucare enano, almácigo, jobo, ciruela del país, cassia de Siam, mamey, *pterocarpus, bambú,* bucayo

ZONA No. 2 — Suelos Profundos de la Costa Húmeda

Suelos moderadamente a bien drenados - series: Bayamón, Lares, Moca, Coto, Matanzas, Vega Alta, Camagüey, Santa Clara, Dominguito, Toa, Estación, Río Piedras, Torres, Vía, Arenas de la costa, Sabana Seca, Vega Alta, Islote, Múcara, Juncos, Sabana, Daguao y otras series similares.

Sitio No. 2a - Cerros
Especies: *maría, roble, casuarina,* cassia de Siam, almácigo, jagüey

Sitio No. 2b. - Laderas
Especies: *maría, roble, casuarina, gliricidia,* bucare enano, almácigo, jagüey, jobo, ciruela del país, cassia de Siam, mamey, *pterocarpus, bambú,* bucayo

Sitio No. 2c - Llanuras y aluviones
Especies: *teca, caoba hondureña, casuarina, maría,* jagüey, bucare enano, almácigo, jobo, ciruela del país, cassia de Siam, emajagüilla, mamey, *gliricida, roble, pterocarpus, samán,* bucare, *bambú,* bucayo

Suelos mal drenados - series: Josefa, Irurena, Palmas Altas, Yabucoa, Piñones, Córcega, Coloso, Fortuna, suelos orgánicos y turbas y otras series similares
Sitio No. 2d - Pantanos de la costa y manglares

Especies: casuarina, emajagüilla (crecen bien en los bordes de los manglares)

bucare 1/ (crece espontáneamente en pantanos de agua dulce). Muchas de las especies del sitio anterior crecen bien aquí dependiendo del drenaje.

COSTA SECA

Todo terreno a 500 pies o menos de elevación en la costa sur y en las laderas al sur de la Cordillera principiando en el valle del Río Guanajibo hacia el suroeste y luego a lo largo de la costa hasta el Río Patillas en el este.

ZONA No. 3 — Suelos Poco Profundos de la Costa Sur

Series de suelos - Aguilita, Ensenada, Lajas, San Germán, Jácana y otras series similares

Sitio No. 3a - Cerros y laderas expuestas
Especie: Almácigo

Sitio No. 3b - Laderas protegidas y valles
Especie: *Casuarina, Cassia Amarilla 3/, gliricida, almácigo,* Jagüey, Casia de Siam.

ZONA No. 4 Suelos Profundos de la Costa Seca

Suelos adecuadamente bien drenados - series: San Antón, Machete, Jauca, Meros, Vives, Altura, Coamo, Fraternidad, Fe, Santa Isabel, Amelia, Paso Seco y otras series similares

Sitio No. 4a. - Llanuras y aluviones
Especies: *samán, casuarina, cassia amarilla, caoba Honduras, teca, gliricidia,* almácigo, jagüey, cassia de Siam, emajaguilla 2/

Suelos con drenaje imperfecto - series: Guánica, Vayas, Aguirre, Reparada, Ursula y suelos orgánicos y turba. Existe poca información en cuanto a la adaptabilidad de especiees útiles. La casuasina crece cuando el área no se inunda muy a menudo. La emajagüilla tolera sitios de drenaje pobre. Muchas de las especies del sitio anterior crecen aquí dependiendo del drenaje. (Fig. 2).

Fig. 2 - Vista representativa de los Suelos Profundos de la Costa Seca (Zona No. 4) Sitio No. 4a. el que sin embargo, no está considerado zona forestal por su topografía llana y calidad del suelo, que lo hace muy deseable para la agricultura. El bosque abierto contiene mayormente árboles de almácigo cerca de Salinas.

1/ bucare — Erythrina glauca
2/ La caoba dominicana crece bien y está muy adaptada a estos pero no se recomienda su siembra debido a que está siendo afectada seriamente por una enfermedad muy seria.

3/ La cassia amarilla sufre del ataque de una enfermedad que mata los árboles. Su futuro depende en gran parte del curso de esta enfermedad.

INTERIOR MONTAÑOSO

Todo el terreno sobre los 500 pies de elevación (exceptuando la zona caliza húmeda en la costa norte) y dividido mayormente en dos subregiones incluyendo las montañas al sur y al suroeste de la Cordillera Central que reciben menos de 60 pulgadas de lluvia anualmente, y las montañas más húmedas en el resto del interior montañoso.

ZONA No. 5 — Laderas Secas en el Interior Montañoso

Series de suelo - Rosario, Descalabrado, Jácana, Guayama, Múcara y otras series similares

Fig. 3 - Ladera de suelos lómicos poco profundos al sur de la Cordillera Central mirando hacia Coamo. Es representativa de la Zona No. 5 - Laderas Secas en Interior Montañoso. La foto incluye mayormente el Sitio No. 5a. En la base de esta ladera se encuentra el Sitio No. 5b en la ladera protegida pero hacia la izquierda fuera de lo encerrado por esta foto.

Sitio No. 5a - Cerros y laderas con orientación este y sur
Sitio muy difícil debido a los efectos de la sequía y de la exposición. Debe estimularse la regeneración del monte natural. Si es necesario hacer plantaciones maría y roble están entre las mejores especies. Almácigo se propaga bien por medio de esquejes.

Sitio No. 5b - Laderas protegidas y valles
Especies: *Teca, caoba Honduras, casuarina, samán, maría, roble,* bucare enano, jobo, *gliricidia,* jagüey, almácigo, ciruela del país, cassia de Siam, mamey, *cassia amarilla, guamá venezolano, bambú,* bucayo (Fig. 3).

ZONA No. 6 — Interior Montañoso Húmedo a Menos de 2200 pies de Elevación

Series de suelo - Utuado, Panduras, Cayaguá, Nipe, Catalina, Alonso, Cialitos, Múcara, Picachos, Naranjito, Sabana y otras series similares.

Sitio No. 6a - Cerros y laderas expuestas
Especies: *Eucalipto, roble, casuarina, maría,* bucare enano, jobo, ciruela del país, *gliricidia,* jagüey, mamey, *guaba del país, guamá venezolano, bambú*

Sitio No. 6b - Laderas protegidas y valles
Especies: *María, caoba Honduras, casuarina, teca, eucalipto,* bucare enano, jobo, *gliricidia,* ciruela del país, *guamá venezolano,* jagüey, *roble, cassia de Siam.* mamey, *guaba del país,* (Fig. 4).

ZONA No. 7 - Interior Montañoso muy Húmedo sobre los 2200 pies de Elevación

Series de suelo - Alonso, Los Guineos, Catalina, Cialitos, Múcara y otras series similares

Los suelos son más plásticos y pesados que en las elevaciones más bajas e incluyen la zona más arriba de la zona de café. La degradación del suelo se hace muy evidente poco después de los desmontes y el suelo arcilloso es entonces propio solamente para

las especies más acomodaticias como el eucalipto y el roble.

Sitio No. 7a - Cerros y laderas expuestas
Especies: *Eucalipto*, *roble*, bucare enano, jagüey, *guaba del país*, *guamá venezolano*
Sitio No. 7b - Laderas protegidas y valles
Especies: Guaraguao, *eucalipto*, bucare enano, jagüey, *roble*, *guaba del país*, *guamá venezolano*, *bambú*

La principal dificultad que ha tenido el personal de campo en la interpretación de la tabla de adaptabilidad ha sido en poder localizar las áreas respectivas dentro de las distintas siete zonas en que se ha dividido la isla. Para obtener la zona se consulta directamente la tabla a continuación y entonces se buscan las especies que le corresponden al sitio y a la zona en particular usando la tabla de adaptabilidad.

TABLA 3 — LOCALIZACION DE LAS ZONAS DE SIEMBRA POR BARRIOS Y MUNICIPALIDADES

MUNICIPIO Y BARRIO	ZONA
ADJUNTAS	
Garzas, Tanamá, Guilarte, y sobre 2,200 pies de elevación en Guayabo Dulce	7
Barrios restantes	6
AGUADA	
Sobre 500 pies de elevación en Atalaya y Cerro Gordo	6
Barrios restantes	2
AGUADILLA	
Caimital Bajo, Victoria, y suelos poco profundos en Camaseyes y	

Fig. 4 - Laderas de suelos arenosos lómico-profundos sobre el embalse de Caonillas en Utuado pertenecientes a la Zona No. 6 - Interior Montañoso Húmedo a menos de 2200 pies de elevación. La mayor parte del área ilustrada por esta foto cae dentro del Sitio No. 6a. El fondo del pequeño valle a la derecha cae dentro del Sitio No. 6b.

Arenales 1
Barrios restantes 2

AGUAS BUENAS 6

AIBONITO 6

AÑASCO

Playa, Añasco Abajo, Añasco Arriba, Río Cañas, Carreras, Espino, Cidra y bajo 500 pies de elevación en Hatillo, Piñales, Caracol, Quebrada Larga, Ovejas y Marías 2
Barrios restantes 6

ARECIBO

Esperanza, Hato Viejo, Río Arriba y suelos poco profundos en Garrochales, Hato Arriba, Miraflores, Sabana Hoyos, Dominguito y Arrozal 1
Barrios restantes 2

ARROYO

Sobre 500 pies de elevación en Yaurel 5
Barrios restantes 4

BARCELONETA

Suelos poco profundos en Garrochales, Florida Adentro y Florida Afuera 1
Barrios restantes 2

BARRANQUITAS 6

BAYAMON

Nuevo, Dajaos, Santa Olaya y Guaraguao Arriba 6
Barrios restantes 2

CABO ROJO

Boquerón, Pedernales, Llanos Costa, Llanos Tuna y suelos poco profundos en Monte Grande 3
Barrios restantes 4

CAGUAS

San Salvador, Beatriz y sobre 500 pies de elevación en Tomás de Castro, Borinquen y Cañaboncito
Barrios restantes 2

CAMUY

Suelos poco profundos en Piedra Gorda, Abra Honda, Santiago y Puertos 1
Barrios restantes 2

CAROLINA

Barrazas, Cerro Gordo, Carruzos y Cedros 6
Barrios restantes 2

CATAÑO 2

CAYEY

Sobre 2,200 pies de elevación en Farallón 7
Barrios restantes 6

CEIBA

Sobre 500 pies de elevación en Río Abajo 6
Barrios restantes 2

CIALES

Hato Viejo y suelos poco profundos en Cordillera y Frontón 1
Suelos profundos en Cordillera y Frontón y bajo 500 pies de elevación en Pesas y Jaguas 2
Cialitos, Pozas, sobre 500 pies de elevación en Pesas y Jaguas y bajo 2,200 pies de elevación en Toro Negro 6
Sobre 2,200 pies de elevación en Toro Negro 7

CIDRA 6

COAMO

Los Llanos y San Ildefonso y bajo 500 pies de elevación en Cuyón, Palmarejo, Santa Catalina y Pasto 4
Sobre 2,000 pies de elevación en Pulguillas, Hayales y Pasto 6
Barrios restantes 5

COMERIO 6

COROZAL

Suelos poco profundos en Abras .. 1
Cibuco, bajo 500 pies de eleva-

ción en Palmarejo y suelos más profundos en Abras 2
Barrios restantes 6

DORADO

Suelos poco profundos en Maguayo, Río Abajo y Espinosa 1
Barrios restantes 2

FAJARDO

Sobre 500 pies de elevación en Río Arriba 6
Barrios restantes 2

GUANICA

Suelos poco profundos en Ensenada, Ciénaga, Montalva, Carenero, Cañas y Susúa Baja 3
Barrios restantes 4

GUAYAMA

Machete, Jobos, Guayama y Algarrobo 4
Carite 6
Barrios restantes 5

GUAYANILLA

Quebradas, Consejo, Llano, Macaná y suelos poco profundos en Boca, Cedro, Indios, Jaguas y Magas 3
Rufina, Playa y suelos profundos en Boca, Cedro, Indios, Jaguas y Magas 4
Barrero, Quebrada Honda y Sierra Baja 5
Pasto y Jagua Pasto:
Sobre los 2,200 pies 6
Bajo los 2,200 pies 7

GUAYNABO

Sobre 500 pies de elevación en Guaraguao y Sonadora 6
Barrios restantes 2

GURABO

Celada, Jagual y bajo 500 pies de elevación en Rincón, Navarro, Hato Nuevo, Mamey y Jaguas .. 2
Barrios restantes 6

HATILLO

Suelos poco profundos en Bayaney, Aibonito, Buena Vista, Campo Alegre, Naranjito, Corcovado, Capaez, Carrizales, y Hatillo 1
Barrios restantes 2

HORMIGUEROS 2

HUMACAO 2

ISABELA

Suelos poco profundos en Arenales Altos, Galateo Alto y Planas .. 1
Barrios restantes 2

JAYUYA

Mameyes Arriba y bajo 2,000 pies de elevación en Jayuya Abajo, Veguitas, Río Grande, Coabey y Collores 6
Barrios restantes 7

JUANA DIAZ

Emajagual, Río Cañas Arriba, y suelos poco profundos en Amuelas, Tijeras, Jacaguas, Callabo y Guayabal 3
Collores - Bajo 2,200 pies de elevación: Suelos poco profundos 5
Suelos profundos 6
Sobre 2,200 pies de elevación 7
Barrios restantes 4

JUNCOS

Caimito y sobre 500 pies de elevación en Gurabo Abajo, Gurabo Arriba y Valenciano Arriba 6
Barrios restantes 2

LAJAS

Suelos poco profundos en Llanos, Palmarejo, Parguera, Candelaria, Paría, Lajas y Lajas Arriba 3
Barrios restantes 4

LARES

Suelos poco profundos en Callejones, Piletas, Lares y Pueblo 1
Suelos profundos en Callejones, Piletas, Lares y Pueblo 2

Bajo 500 pies de elevación en Buenos Aires y Espino 4
Barrios restantes 6

LAS MARIAS 6

LAS PIEDRAS

Sobre 500 pies de elevación en Montones y El Río 6
Barrios restantes 2

LOIZA

Canóvanas, Medianía Alta, Medianía Baja, Torrecilla Baja, Torrecilla Alta y bajo 500 pies de elevación en Hato Puerco 2
Barrios restantes 6

LUQUILLO

Juan Martín, Pitahaya, Mata de Plátano y Mameyes I 2
Barrios restantes 6

MANATI

Suelos poco profundos en Pueblo Poniente, Pueblo Saliente, Bajura Adentro, Coto Sur, Río Arriba Poniente y Río Arriba Saliente.. 1
Barrios restantes 2

MARICAO

Sobre 2,200 pies de elevación en Indiera Alta 7
Barrios restantes 6

MAUNABO

Bajo 500 pies de elevación en Calzada, Emajagua, Quebrada Arenas, Talante y Palo Seco 2
Barrios restantes 6

MAYAGUEZ

Guanajibo, Río Hondo, Malezas, Quebrada Grande, Mayagüez Arriba, Miradero, Algarrobos, Sabanetas, Leguísamo y bajo 500 pies de elevación en Río Cañas Abajo 2
Barrios restantes 6

MOCA

Suelos poco profundos en Aceitunas, Cuchillas, Rocha y Centro ... 1
Barrios restantes 2

MOROVIS

Suelos poco profundos en Barahona, Fránquez, Monte Llano, Morovis Norte, Torrecillas y Unibón 1
Cuchillas, Morovis Sur, San Lorenzo y suelos profundos en los Barrios citados arriba 2
Barrios restantes 6

NAGUABO

Sobre 500 pies de elevación en Peña Pobre, Duque, Maizales y Río Blanco 6
Barrios restantes 2

NARANJITO

Lomas, Guadiana, y bajo 500 pies pies de elevación en Achiote y Barrio Nuevo 2
Barrios restantes 6

OROCOVIS

Sobre 2,200 pies de elevación en Ala de la Piedra, Bauta Abajo, Bermejales, Bauta Arriba y Sabana 7
Barrios restantes 6

PATILLAS

Pollos, Cacao Bajo, Cacao Alto y bajo 500 pies de elevación en Acaboa, Guardarraya, Mamey, Jagual, Quebrada Arriba y Río 2
Barrios restantes 6

PEÑUELAS

Coto y suelos poco profundos en Cuebas, Tallaboa Poniente, Tallaboa Saliente y Encarnación 3
Tallaboa Alta, suelos profundos en Cuebas, Tallaboa Saliente, Tallaboa Poniente y Encarnación, y bajo 500 pies de elevación en Santo Domingo y Quebrada Ceiba ... 4
Macana y sobre 500 pies de eleva-

ción en Santo Domingo y Quebrada Ceiba 5
Barreal, Jaguas y bajo 2,200 pies de elevación en Rucio 6
Sobre 2,200 pies de elevación en Rucio 7

PONCE

Magueyes Urbano, Portugués Urbano, Cañas Magueyes y suelos poco profundos en Coto Laurel y Sabanetas y suelos poco profundos bajo 500 pies de elevación en Portugués 3
Tibes, Machuelo Arriba, Marueño, Quebrada Limón, Monte Llano y sobre 500 pies de elevación en Portugués y Real 5
San Patricio, Guaraguao, Maraguez y bajo 2,200 pies de elevación en Anón 6
Sobre 2,200 pies de elevación en Anón 7
Barrios restantes 4

QUEBRADILLAS

Suelos poco profundos en Cacao, San Antonio, Guajataca, Charcas y San José 1
Barrios restantes 2

RINCON

Sobre 500 pies de elevación en Jaguey y Atalaya 6
Barrios restantes 2

RIO GRANDE

Guzmán Abajo, Herrera, Zarzal, Ciénaga Baja y bajo 500 pies de elevación en Jiménez y Mameyes II 2
Sobre 500 pies de elevación en Jiménez y Mameyes II pero bajo 2,200 pies de elevación 6
Barrios restantes 7

RIO PIEDRAS

Sobre 500 pies de elevación en y Quebrada Arenas y Cupey Alto 6
Barrios restantes 2
Suelos profundos en Rayo, Susúa y Machuchal 4
Santana y Tabonuco 5
Barrios restantes 3

SALINAS

Aguirre, Lapa, Río Jueyes y bajo 500 pies de elevación en Quebrada Yeguas 4
Barrios restantes 5

SAN GERMAN

Cotui, Ancones, Tuna, Guamá y suelos poco profundos en Maresúa, Minillas, Retiro, Sabana Eneas, Duey Bajo, Hoconuco Bajo, Sabana Grande Abajo y bajo 500 pies de elevación en Caín Alto 3
Caín Bajo y suelos profundos en Sabana Eneas, Maresúa, Minillas, Retiro, Duey Bajo, Hoconuco Bajo y Sabana Grande Abajo 4
Rosario Bajo 2
Barrios restantes 5

SAN JUAN 2

SAN LORENZO

Espino y sobre 500 pies de elevacion en Hato Quemados, Quebrada Honda, Cerro Gordo y Quebrada Arenas 6
Barrios restantes 2

SAN SEBASTIAN

Suelos pocos profundos en Juncal, Magos, Eneas, Guajataca, Aibonito, Cibao, Robles, Salto, Hoya Mala, Hato Arriba, Guatemala, Cidral y Piedras Blancas .. 1
Barrios restantes 2

SANTA ISABEL

Suelos poco profundos en Descalabrado y Jauca 2 3
Barrios restantes 4

TOA ALTA

Suelos profundos en Galateo, Piñas, Contorno y Mucarabones 2

Barrios restantes 1

TOA BAJA

Suelos poco profundos en Candelaria 1
Barrios restantes 2

TRUJILLO ALTO

Cuevas y Dos Bocas 2
Barrios restantes 1

UTUADO

Angeles, Caguana, Río Abajo, Santa Rosa:
Suelos poco profundos 1
Suelos profundos 2
Barrios restantes 6

VEGA ALTA

Suelos poco profundos en Espinosa, Bajura, Maricao, Candelaria, Mavilla y Cienegueta 1
Barrios restantes 2

VEGA BAJA

Suelos poco profundos en Río Abajo, Pugnado Afuera, Río Arriba, Almirante Norte, Almirante Sur, Quebrada Arenas y Pugnado Adentro 1
Barrios restantes 2

VILLALBA

Bajo 500 pies de elevación en Hato Puerco Abajo y Villalba Abajo 4
Caonillas Abajo, Caonillas Arriba, sobre 500 pies de elevación en Hato Puerco Abajo y Villalba Abajo y bajo 1,500 pies de elevación en Hato Puerco Arriba 5
Sobre 1,500 pies de elevación en Hato Puerco Arriba y bajo 2,000 pies de elevación en Villalba Arriba y Vacas 6
Barrios restantes 7

YABUCOA

Camino Nuevo, Juan Martín, Yabucoa, Playa, Limones, Camino Nuevo, Aguacate y bajo 500 pies de elevación en Calabazas y Tejas 2
Barrios restantes 6

YAUCO

Quebradas, Almácigo Alto, Susúa Alta, suelos poco profundos en Almácigo Bajo, Caimito, Diego Hernández, Jácana, Barina y Susúa Baja, y bajo 500 pies de elevación en Algarrobo 3
Sierra Alta, Duey, Vegas, Collores, y sobre 500 pies de elevación en Algarrobo 5
Aguas Blancas, Naranjo, Rancheras, Río Prieto, Frailes y Rubias 6
Barrios restantes 4

EPOCA DE SIEMBRA

La experiencia demuestra que la siembra de árboles a raíz desnuda solo tiene éxito durante épocas de lluvia y especialmetne si el suelo continúa húmedo durante algún tiempo después de la siembra hasta que el arbolito esté establecido. En las zonas más áridas como en las números 3, 4 y 5 la siembra a raíz desnuda es arriesgada a menos que se puedan regar las plantitas hasta que estén establecidas, algo que resultará costoso.

En estas zonas, especialmente en las más secas, es aconsejable sembrar las plantas con un pilón de tierra si se interesa obtener una sobrevivencia aceptable. Muchas de las especies durante años muy favorables sobreviven sembradas a raíz desnuda pero en años normales no pueden resistir los períodos de sequía. Ejemplos son la caoba dominicana, la cassia de siam, la casuarina, el samán, etc. Las especies que se siembran directamente por semilla tales como la maría y la cassia pueden establecerse a pesar de la sequía, lo mismo que las especies que se propagan vegetativamente como el jobo, la glicirida, el almácigo, jagüey, aunque a veces el porcentaje de esquejes prendidos no es alto.

En la Tabla 4 hemos asumido que la me-

jor sobrevivencia se obtiene cuando la lluvia promedio durante el mes de siembra alcanza o excede 6 pulgadas de lluvia y no baja de 4 pulgadas, tanto en el mes anterior al de la siembra como en el mes que le sigue. La tabla siguiente se preparó marcando en un mapa y relacionando los datos de lluvia durante 40 años. Se hicierón excepciones a esta regla en la costa sur donde ningún mes llena los requisitos pero sin embargo, se siembra con éxito en algunos años durante los meses más lluviososos. También los meses de enero y marzo se excluyeron porque están restringidos a tan pocas áreas, que la producción de material de vivero no se justifica específicamente para estos meses.

TABLA 4 — MESES PROPICIOS PARA LA SIEMBRA DE ARBOLES EN PUERTO RICO

MUNICIPIO Y BARRIO	MES DE SIEMBRA
ADJUNTAS	5-11
AGUADA	
Atalaya, Cerro Gordo, Laguna, Naranjo, Mamey, Marías, Guanábano y Mal Paso	5-10
Barrios restantes	7-10
AGUADILLA	10
AGUAS BUENAS	5-11
AIBONITO	8-10
AÑASCO	5-10
ARECIBO	
Garrochales, Hato Abajo, Cambalache, Islote, Santana y Factor, Hato Arriba, Miraflores, Sabana Hoyos, Domingo Ruiz, Arenalejos y Tanamá	11
	9-11
Carreras, Dominguito y Arrozal	7-11
Esperanza, Hato Viejo y Río Arriba	5-11
ARROYO	
Palmas y Guácimas	8-10
Barrios restantes	7-11
BARCELONETA	
Florida Adentro	5-11
Florida Afuera	9-11
Barrios restantes	11
BARRANQUITAS	8-10
BAYAMON	
Nuevo y Dajaos	5, 7-12
Barrios restantes	5-12
CABO ROJO	
Boquerón, Pedernales, Llanos Costa, Llanos y Tuna	9-10
Barios restantes	6-10
CAGUAS	5-11
CAMUY	
Piedra Gorda, Abra Honda y Santiago	8-11
Cibao y Quebrada	5-11
Barrios restantes	11
CAROLINA	
Hoyo Mulas, Sabana Abajo y Cangrejos Arriba	6-11
Barrios restantes	5-12
CATAÑO	6-11
CAYEY	
Cercadillo, Lapa, Pasto Viejo, Pedro Avila, Matón Arriba y Piedras	8-10
Matón Abajo	7-10
Jájome Bajo, Sumido, Toita y Rincón	7-11
Jájome Alto, Culebras Alto, Culebras Bajo, Quebrada Arriba, Monte Llano	6-11
Barrios restantes	5-11
CEIBA	
Machos, Guayacán y Quebrada Seca	9-10
Saco, Daguao y Chupacallos	8-11
Río Abajo	5-11

CIALES

Pozas y Jaguas 5-12
Barrios restantes 5-11

CIDRA

Honduras y Salto 7-10
Toita, Rabanal, Río Abajo, Sud y Rincón 6-11
Barrios restantes 5-11

COAMO

Los Llanos y San Ildefonso 9-10
Coamo Arriba y bajo 2,000 pies de elevación en Pedro García, Hayales y Pulguillas 5-11
Barrios restantes 8-10

COMERIO

Piñas y Río Hondo 7-10
Vega Redonda y Palomas 7-11
Barrios restantes 7-12

COROZAL 5, 7-12

DORADO

Higuillar y Mameyal 7-11
Maguayo, Río Abajo y Espinosa 6-11

FAJARDO

Cabezas, Quebrada Vueltas, Puerto Real, Sardinera y Demajagua 9-11
Fajardo Norte, Fajardo Sur, Fajardo Oeste, Quebrada Fajardo, Florencio y Naranjo y bajo 500 pies de elevación en Río Arriba 8-11
Sobre 500 pies de elevación en Río Arriba 6-11

GUANICA 9-10

GUAYAMA

Machete, Jobos, Guayama y Algarrobo 9-10
Palmas, Pozo Hondo, Carmen y Caimital 8-10
Guamaní 7-11
Carite 5-11

GUAYANILLA

Consejo, Llano, Macaná, Barrero, Quebrada Honda y Sierra Baja 7-10
Pasto y Jagua Pasto 6-10
Barrios restantes 9-10

GUAYNABO 5-12

GURABO 5-11

HATILLO

Bayaney y Aibonito 5-11
Buena Vista y Campo Alegre ... 7-11
Naranjito y Corcovado 10-11
Capaez, Carrizales y Hatillo 11

HORMIGUEROS 5-11

HUMACAO

Candelario Bajo, Buena Vista, Río Abajo y Punta Santiago ... 6-11
Barrios restantes 5-11

ISABELA

Suelos poco profundos en Arenales Altos, Galateo Alto y Planas ... 7-11
Barrios restantes 10

JAYUYA 5-11

JUANA DIAZ

Jacaguas, Callabo y Guayabal . 8-10
Collores 7-10
Barrios restantes 9-10

JUNCOS 5-11

LAJAS 9-10

LARES 5-11

LAS MARIAS 5-11

LAS PIEDRAS 5-11

LOIZA

Canóvanas, Medianía Alta, Medianía Baja, Torrecilla Baja, Torrecilla Alta y bajo 500 pies de elevación en Hato Puerco 8-11
Barrios restantes 5-12

LUQUILLO

Juan Martín, Pitahaya, Mata de

Plátano y Mameyes I 8-11
Barrio restantes 5-12

MANATI

Tierras Nuevas Poniente y Tierras Nuevas Saliente 11
Bajura Afuera y Pueblo Poniente y Pueblo Saliente 10-11
Bajura Adentro y Coto Sur 9-11
Río Arriba Poniente y Río Arriba Saliente 8-11

MARICAO 5-11

MAUNABO

Bajo 500 pies de elevación en Calzada y Emajagua 6-11
Barrios restantes 5-11

MAYAGUEZ 5-10

MOCA 5-10

MOROVIS 5-12

NAGUABO

Daguao 8-10
Santiago y Lima 7-11
Húcares, Mariana, Río 6-11
Peña Pobre, Duque y Maizales 5-11
Río Blanco 5-12

NARANJITO 5, 7-12

OROCOVIS

Ala de la Piedra 5-11
Damián Arriba, Pellejas, Barros, Orocovis, Gato, Mata de Cañas y Bauta Abajo 6-12
Bermejales, Bauta Arriba y Sabana 7-10
Botijas y Saltos 6-10
Cacos y Collores 5-12

PATILLAS

Pollos, Bajo y bajo 500 pies de elevación en Acaboa y Guardarraya 7-10
Barrios restantes 5-11

PEÑUELAS

Tallaboa Poniente, Tallaboa Saliente y Encarnación 9-10
Barreal, Jaguas y Rucio 7-10
Barrios restantes 8-10

PONCE

Magueyes, Machuelo Arriba, Marueño y Quebrada Limón 8-10
Monte Llano, Guaraguao y Maraguez 7-10
San Patricio y Anón 5-11
Barrios restantes 10-11

QUEBRADILLAS

San Antonio, Guajataca y Charcas 8-11
Barrios restantes 11

RINCON 7-10

RIO GRANDE

Herrera y Zarzal 8-11
Ciénaga Baja 7-11
Barrios restantes 5-12

RIO PIEDRAS 5-12

SABANA GRANDE

Santana y Tabonuco 7-10
Barrios restantes 8-10

SALINAS

Aguirre, Lapa, Río Jueyes y bajo 500 pies de elevación en Quebrada Yeguas 9-10
Barrios restantes 8-10

SAN GERMAN

Cotui, Ancones, Tuna, Maresúa, Minillas y Retiro 7-10
Guamá, Sabana Eneas, Sabana Grande Abajo, Caín Alto y Caín Bajo 6-10
Barrios restantes 5-10

SAN JUAN 5-11

SAN LORENZO 5-11

SAN SEBASTIAN

Robles, Salto, Hoyas Malas, Hato Arriba, Guatemala, Cidral, Pie-

dras Blancas, Culebrinas, Pozas, Sonador y Alto Sano 5-10
Barrios restantes 5-11

SANTA ISABEL 9-10

TOA ALTA 5-12

TOA BAJA

Candelaria 6-12
Barrios restantes 7-11

TRUJILLO ALTO 5-12

UTUADO 5-11

VEGA ALTA

Sabana 9-11
Espinosa 6-11
Cienegueta 5-12
Barrios restantes 6-12

VEGA BAJA

Yeguada y Puerto Nuevo 11
Algarrobo, Cabo Caribe y Cibuco 9-11
Ceiba 7-11
Río Abajo y Pugnado Afuera .. 8-11
Barrios restantes 6-12

VILLALBA

Villalba Arriba y Vacas 7-10
Barrios restantes 8-10

YABUCOA

Camino Nuevo, Juan Martín, Yabucoa y Playa 6-11
Barrios restantes 5-11

YAUCO

Jácana, Barina y Susúa Baja .. 9-10
Quebradas, Almácigo Alto, Susúa Alta, Almácigo Bajo, Caimito y Diego Hernández y bajo 500 pies de elevación en Algarrobo 8-10
Sierra Alta, Duey, Vegas, Collores y sobre 500 pies de elevación en Algarrobo 7-10
Aguas Blancas, Naranjo, Rancheras, Río Prieto, Frailes y Rubias 6-10

The Utilization of Teak in Trinidad

PHILIP ROSS, Ph.D.
Imperial College of Tropical Agriculture

Introduction

Teak plantations were first established in Trinidad in 1913 when C. S. Rodgers, Forest Officer in Trinidad, looking for a first quality wood, introduced teak seeds from Burma and planted them in the Southern Watershed Reserve. Small areas were planted each succeeding year until 1920 when the total area of teak plantations was 71 acres. In 1928 a definite teak plantation program was established, and teak was planted on a considerably larger scale. Fresh seeds were brought in from India in 1936 (2). Since then the Forest Department has set up a general plan for teak plantations calling for 800 acres per annum to be planted in teak, and this target was reached in 1956 and 1957. As Trinidad teak falls between Classes I and II of the Indian Nilembur plantation quality class scale, the yield of the final fellings of teak by 1990 have been estimated to be not less than 1.5 million cubic feet a year (10). In the meantime, the teak plantations are producing wood for fences, building and construction lumber, and posts and poles.

Teak Planting

Trinidad teak plantations are established by means of the Burma taungya system. Local farmers sign a contract with the Forest Department under which they are allowed the use of the land rent-free for a period of 15 months to plant certain food crops; in return they must clear the land of the natural forest, keep their land free of weeds, and tend the teak stump plants which are set out in the field. (For a more detailed account of this system see Cater, 1941.) The teak stump plants from a nursery are spaced six feet by six feet, 1.210 teak plants per acre. Because of the rapid growth of the closely planted teak trees, thinning operations must be carrried out every five years.

The Utilization of Teak Thinnings

The processing plant.—In 1955 the Forest Department utilization program for teak thinnings was given the name "Brickfield Forest Industries". Located at one center in Brickfield are a fencing factory, a sawmill with a Gorwood gangsaw and a resaw, and a hot and cold creosoting plant. The gangsaw is not run in competition with the 95 commercial sawmills in Trinidad because it is designated to cut thinnings up to ten inches in diameter at the butt. The average sawmill cannot handle these smaller trees economically. Larger thinnings are sent to private sawmills on the island. Teak plantations on private estates are relatively young and do not supply any sizeable quantity of teak wood.

The fencing factory.—Split teak fencing utilizes thinnings predominantly from plantations five to ten years old. The teak is split into pickets in the field by the contractors as they thin the young plantations. After the pickets are stacked in the factory, the contractors are paid a standard price for each picket. Two men are employed on a piecework basis at the factory to turn out 25-foot lengths of fencing in three standard heights: three feet, four and one-half feet, and six feet. The two men produce 16 lengths of 3-foot fence a day, or fewer lengths if they are working on the taller fences.

The operation of the factory is set up similarly to the split chestnut fencing operation in England. Three pairs of galvanized wire are strung the length of the factory, approximately 53 feet. The wires pass in pairs through a platting, or wire-twisting, machine

which runs along a track underneath the fencing being constructed. One workman inserts a picket through the wires and turns the handle of the platting machine which twists the wires around the picket. The twist in the wires is given in opposite directions to counteract any tendency of the fence to buckle and to prevent the wires in the coils from becoming tangled. After the pickets have been platted into the 53 feet of wire, the middle of the fence is cut to give two 25 foot sections. The two sections are placed on the floor, and the wires are stapled to each picket by the second workman. The first workman, in the meantime, sets up the wires and starts the operation over again. The finished lengths of fencing are rolled up and are dried in the open air for three months before they are treated by hot and cold impregnation at the creosoting plant. Impregnation is necessary to improve the lasting qualities of the pickets which are composed mainly of sap wood.

The efficiency of the operation has been increased by innovations devised to hold the wires. In order to prevent the wires from tangling, the rolls of wire are kept around a cylindrical concrete core at one end of the factory. The wires are led up through galvanized tubes and through a device which maintain the wires in constant tension.

The sawmill.—Under one roof at the sawmill are the Gorwood gangsaw installed in 1954 and a resaw installed in 1956. The gangsaw cuts dimension stock in sizes ranging from two inches by three inches to six inches by six inches. The resaw economically produces one inch by four inch lumber from slabs left by the gangsaw.

Trucks bring the logs from the teak plantations to the sawmill. The logs stored to one side and above the sawmill are gravity-fed to the mill on inclined wooden ramps. The gangsaw will handle logs up to 14 feet. The saw feed is by means of a conveyor chain. The Gorwood gangsaw used at the mill is a modification of the saw designed to convert thinnings from coniferous plantations in the United Kingdom into usable lumber. The gangsaw consists of twin circular saws that can be adjusted to any distance. The hard teak logs are cut by diffuse chrome teeth inserted into the circular saws. The principle behind the use of the Gorwood gangsaw is that small, green, and wet logs can be cut without bowing of the final lumber because the stresses released by one saw are countered by the stresses released by the other. Located at the other end of the sawmill is the roller-fed resaw which also has chrome-plated teeth inserted into the circular saw.

Nine men are employed in the sawmill. The normal procedure is to run a log through the gangsaw twice to produce the squared lumber of a required size. As the squared lumber is passed along the table from the saw to the end of the mill for storage, it passes a circular cut-off saw that squares the ends. A slab, cut from a log by the gangsaw, is sent through the gangsaw once to cut two sides. The slab, which now has three cut surfaces, is then sent through the resaw where one or two laths are cut off depending on the size of the original slab. This use of the resaw is saving valuable lumber that otherwise would be sold for firewood.

The creosoting plant.—Since many timbers in contact with the ground are readily attacked by insects and fungi in the tropics, treatment with some type of preservative is desirable. The easily destroyed sap wood of the teak fencing is impregnated with preservative at the creosoting plant. Also treated are, 6-, 8-, and 10-foot teak poles from the ten and fifteen year old thinnings too small to be cut by the Gorwood saw.

A hot and cold impregnation method is used at the plant. The preservative is a 50:50 mixture of creosote, shipped from the United Kingdom, and dieseline, a gas oil produced on the island. The 14-foot steel tank, containing the hot creosote, is heated beneath by a furnace. Sixty to eighty poles or fencing are introduced when the preservative reaches 160°F and remain in the hot tank for four hours. They are then immediately transferred to the cold tank by means of an overhead

Fig. 1 - The sawmill. The logs on the right are gravity fed to the farther end of the sawmill on an inclined wooden ramp. The sawn lumber is seen as it leaves the mill at the left of the picture.

Fig. 2 - Teak logs that have been sent the Gorwood hangsaw are sent through a second time to cut the remaining two sides.

H-rail and pulley block. The hot tank is reloaded, kept hot for four hours, and allowed to cool. Cooling time is two days during which the first load in the cold tank and the second load in the hot tank absorb the preservative, about six pounds per cubic foot. The system of cooling the hot tank is necessary because the cold tank is slightly smaller in size and will not accommodate the longer poles and the cold tank would have to be

Fig. 3 - The creosoting plant where the fencing rolls and posts are impregnated with a preservative. The fencing rolls on the right are being dried partially before being sent through the plant.

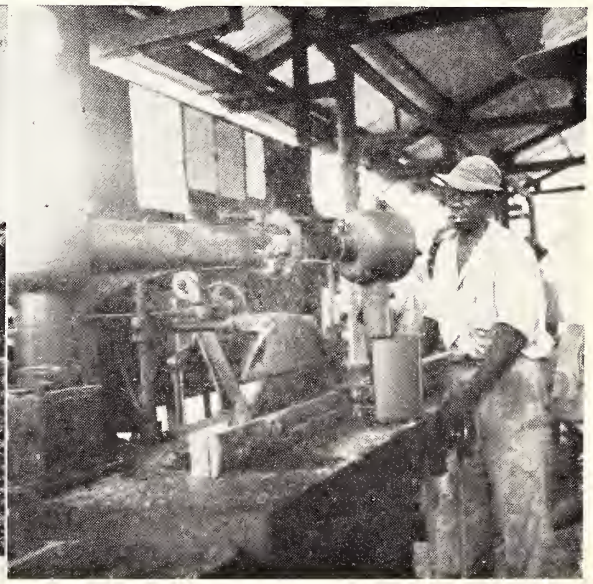

Fig. 4 - Slabs are roller fed through the resaw which economically produces one by four inch stock.

cooled after the first load.

There are two other creosoting plants on the island. The Cocoa Board, operating one at the Centeno cocoa propagating station, before 1954 was obtaining creosoted poles from the plant run by the Forest Department. The other plant is operated by the Government Railway which has a small cylinder in which mora sleepers are pressure treated.

Utilization of thinnings.—Wood is in great demand in Trinidad. The "Administrative Report of the Forest Department for 1956" indicates that the gross imports of sawn coniferous and non-coniferous lumber totaled 1,212,000 cubic feet. The export of non-coniferous sawn lumber was much smaller, only 19,500 cubic feet. The volume of teak wood produced from the thinnings for the same period was 80,600 cubic feet. Teak is being utilized as fast as it can be cut; the demand is greater than the supply.

During 1956, the first full year of operation, the Brickfield Forest Industries earned a net profit of $18,437.00 1/. The fencing factory produced 3,570 rolls of 25-foot lengths of fence. Pickets split in the field were bought from the contractors for 2.4 cents per picket, delivered, and stacked at the factory. The fence rolls are priced according to the height: three foot height rolls sell for $4.50, four foot rolls for $5.50, and six foot rolls for $6.50. The revenue from the sale of the fencing rolls exceeded the expenditure by $6,687.00

Often the teak fences are used around private gardens and homes. They can be seen protecting every school playground and garden in Trinidad and tobago. The fences are not painted, and the wood weathers to an attractive grayish-brown color.

In 1956 the sawmill produced 148,034 board feet of lumber from 24,462 cubic feet of thinnings. The logs for the sawmill are supplied by contractors who fell the teak thinnings marked by the Forest Department's silvicultural staff. The logs, delivered to the sawmill, must have a top dimension of six to ten inches underbark, and they must be in 8-, 10-, 12-, 14-, or 16-foot lengths. The lumber size, two by four inches, is in great demand and usually is bought as it comes from the saw. The sawn teak price is 24 cents per board foot. The revenue from the sawmill exceeded expenditure in 1956 by $5,822.00

The lumber produced by the sawmill is bought by construction companies and is used for rafters, studs, purlins, laths, sills, and joists. A furniture factory buys four inch scantlings and slabs which are used for making collapside chairs and broom handles. Prior to the establishment of the resaw, slabs were sold by the truck load for $5.00 for firewood. The resaw now cuts the slabs into laths and flooring strips.

From the smaller thinnings, poles cut and peeled in the field by the contractors are stacked for partial seasoning for a period of six months outside the creosoting plant. The number of poles treated in the creosoting plant during 1956 was 12,910. Creosoted poles are sold at the following prices: 8-foot lengths, light and heavy weight for $1.00 and $1.50, respectively; 10-foot, light and heavy, $1.50 and $2.00, respectively; and 13-foot, 9-inch poles for $3.00. Untreat poles of equal size are sold at one-half the price of the treated poles. The revenue from the sale of the poles exceeded expenditures by $4,995.00.

The demand for both treated and untreated poles and fence posts is high even through "graveyard" test have indicated that treated fence posts will last twenty years in the ground compared with four to five years of the untreated posts.

The following table summarizes the financial aspect of the Brickfield Forest Industries for the year 1956 (1).

Table 1. Financial Repor tof the Brickfield Forest Industries

1/ The local currency sign $ means British West Indian dollars. The U.S.A. equivalent of the B.W.I. dollor is 58 cents.

All operation expenses	$56,302.00
Other expenses 1/	9,067.00
net profit	18,437.00
	$83,806.00
Revenue	$54,493.00
Stock in hand	29,313.00
	$83,806.00

Summary

Teak plantations have been established in Trinidad to produce a first quality wood for the future. In the meantime the thinnings from the teak plantations are being utilized by the Forest Department's "Brickfield Forest Industries". Located at Brickfield are a fencing factory, a sawmill a Gorwood gangsaw, and a hot and cold creosoting plant.

The fencing factory utilizes split teak pickets from the five and ten year old plantations. Fencing in 25-foot lengths is produced in three heights: three feet, four and one-half feet, and six feet. In 1956, 3,570 rolls of fencing were produced by the factory. Logs that have top dimensions of six to ten inches underbark are sent through the sawmill. The gangsaw cuts lumber in a range of building sizes from two by three inches to six by six inches. The resaw cuts one by four inch stock from the slabs cut by the gangsaw. In 1956, 148,034 board feet of lumber were cut from the teak thinnings. To prevent destruction of poles, posts and fences by insects and fungi, those items are treated in a 50:50 mixture of creosote and gas oil by the hot and cold impregnation method. At the creosoting plant in 1956, 12,910 poles were treated. The net profit for the first year of operation of the Brickfield Forest Industries was $18,437.00 B.W.I.

Fig. 5 - Broom handles and folding chairs manufactured from teak lumber by a furniture factory in Trinidad.

Acknowledgments

This paper was prepared while the writer was associated with the Imperial College of Tropical Agriculture, Trinidad, on a United States Government Fulbright scholarship. The writer is indebted to John Purseglove, Professor of Botany at the College, and to David Moore, Conservator of Forest in Trinidad,

1/ Depreciation, royalties accredited to various coupes for timber supplies, salary of monthly paid field staff, etc.

and his staff for their cooperation and kind assistance during the course of this study.

References

1. Administrative Report, Forest Department, Trinidad and Tobago. 1925-1956.
2. Beard, J.S. The importance of race in teak. The Caribbean Forester 4: 135 - 139. 1943.
3. _____. The natural vegetation of Trinidad. Oxford Forestry Memoirs #20. 194.6
4. Brooks, R.L. Notes on growing teak in Trinidad. 1938.
5. _____. Notes of pure teak plantations in Trinidad. The Caribbean Forester 3:25-28. 1941.
6. Burkill, I.H. *Tectona* in: A dictionary of the economical products of the Malay Peninsula. Vol. 2: 2127-2129. 1935.
7. Cater, J. C. The formation of teak plantations in Trinidad with the assistance of peasant contractors. The Caribbean Forester 2: 147-153. 1941.
8. Encyclopedia Britannica 25: 483---486. 1911.
9. Marshall, R. C. Silviculture of Trinidad and Tobago, B.W.I. 1939.
10. Smeathers, R. A comparative study of the more important mechanical and physical properties of Trinidad and Burma-grown teak. Imperial Forestry Institute Paper #27. 1951.
11. Troup, R.S. Silviculture of Indian trees. 1921.


UNITED STATES
ATLANTIC
OCEAN
GULF OF
MEXICO
BAHAMA
ISLANDS
MEXICO
CUBA
PUERTO
RICO
GUADELOUPE
DOMINICA
MARTINIQUE
STA. LUCIA
JAMAICA
HAITI
DOMINICAN
REPUBLIC
BRITISH
HONDURAS
CARIBBEAN SEA
HONDURAS
GUATEMALA
SALVADOR
NICARAGUA
TRINIDAD
PACIFIC
OCEAN
COSTA
RICA
PANAMA
VENEZUELA
BR.
GUIANA
COLOMBIA